535334

Geometric, Dimensioning and Tolerancing

Materials Conditions and Modifiers

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Material Conditions

- A key concept in geometric tolerancing is the ability to specify tolerances at various part feature material conditions.
- These material condition concepts can only be used when referring to a feature of size (FOS) such as a hole, shaft diameter, tab, etc.
- Three common material conditions used in GD&T are maximum material condition (MMC), least material condition (LMC), and regardless of feature size (RFS).

Outline

- Maximum Material Condition
- Least Material Condition
- Regardless of Feature Size

Maximum Material Condition (MMC)

Definitions

- Maximum material condition (MMC) is the condition in which a feature of size contains the maximum amount of material within the stated limits of size.
- Maximum material virtual size (MMVS), gauge boundary,: Size generated by the collective effect (concerning mating) of the maximum material size (MMS) and the geometrical tolerance followed by the symbol Ⓜ, i.e.
  - for shafts, MMVS = MMS + geometrical tolerance
  - for holes, MMVS = MMS - geometrical tolerance

Maximum Material Condition (MMC)

Definitions (Cont.)

- The MMVS represents the design dimension of the functional gauge.

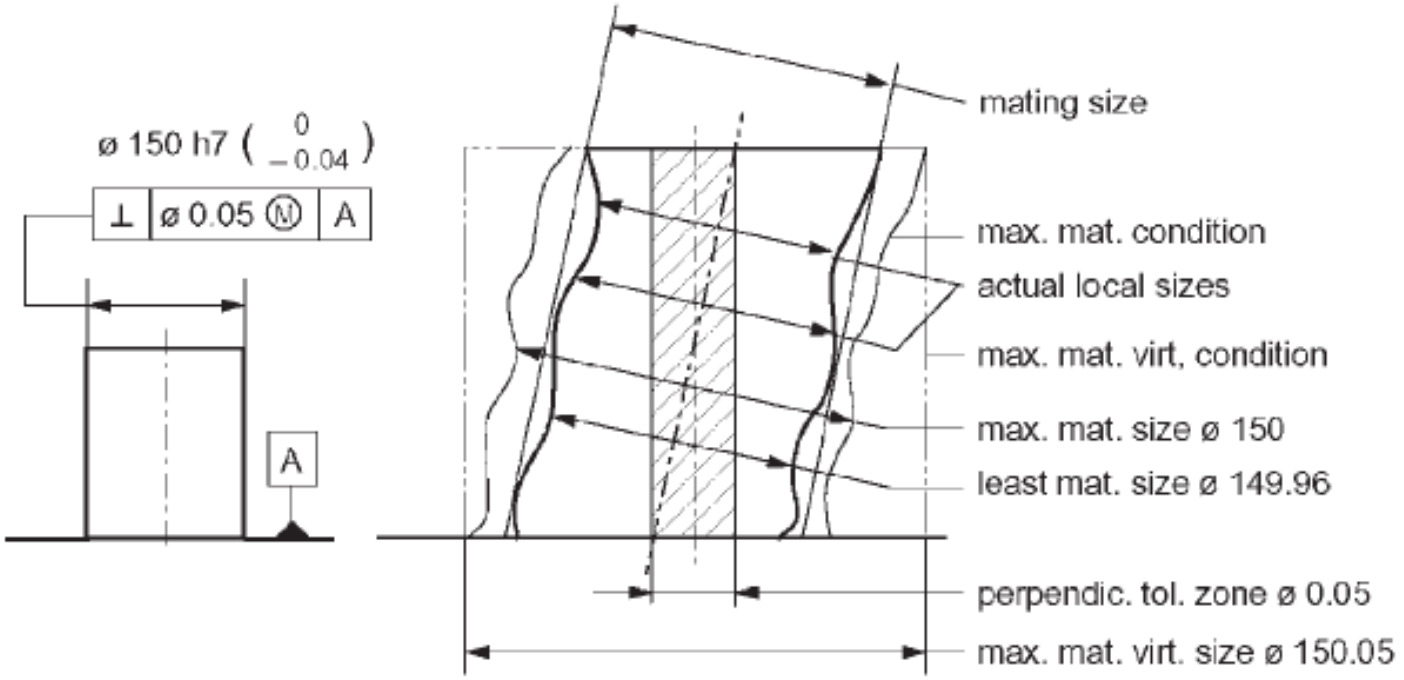


Fig. 9.1 Sizes and conditions of a feature with a related geometrical tolerance

MMC: Applications (1)

- MMC can be applied only to those features with an axis or a median plane (cylindrical features or features composed of two opposite parallel planes).
- This applies normally to clearance fits.

MMC: Applications (2)

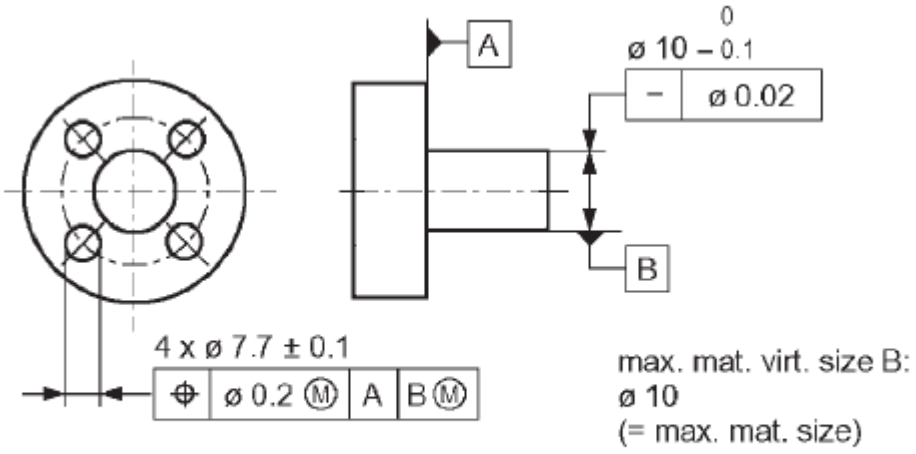


Fig. 9.3 Maximum material virtual size of datum B; form tolerance (straightness) to be disregarded

<- might be wrong

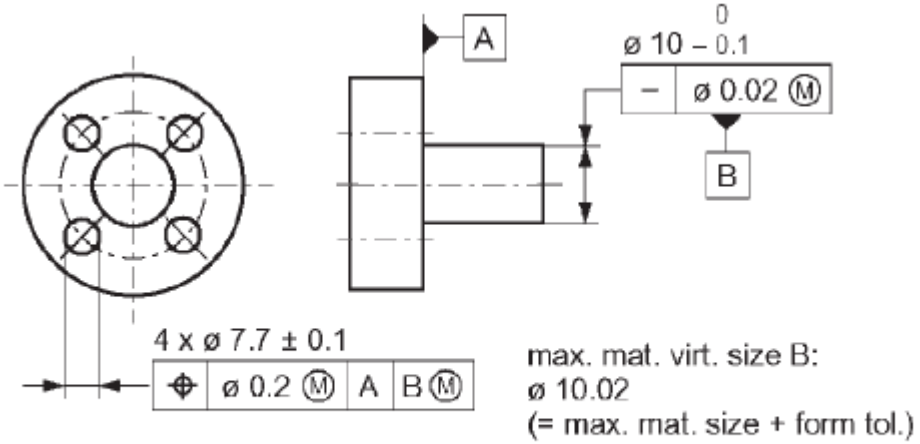


Fig. 9.4 Maximum material virtual size of datum B; form tolerance (straightness) to be regarded

MMC: Applications (2)

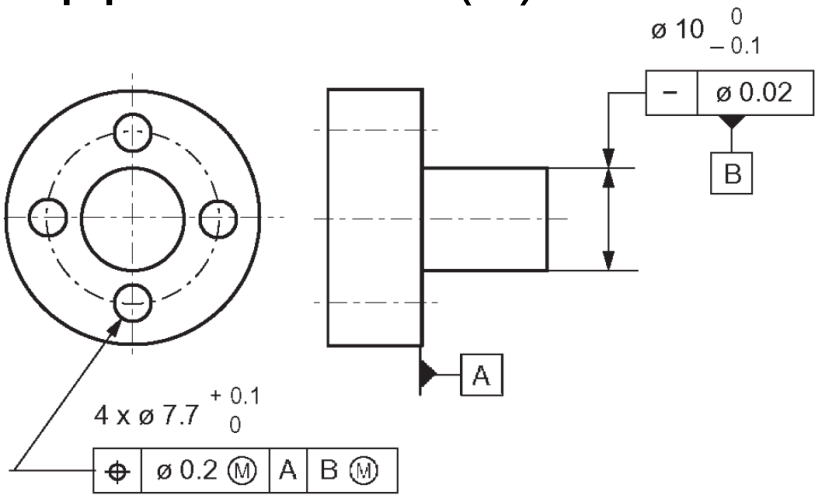


Fig. 21.7 Datum feature (B) with an axis and with a straightness tolerance to the axis (MMVS for B Ⓜ is ø10.02)

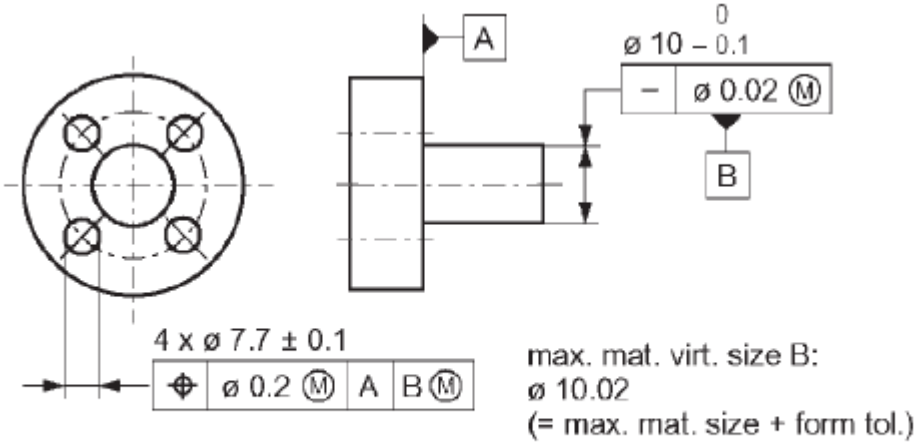


Fig. 9.4 Maximum material virtual size of datum B; form tolerance (straightness) to be regarded

MMC: Applications (3)

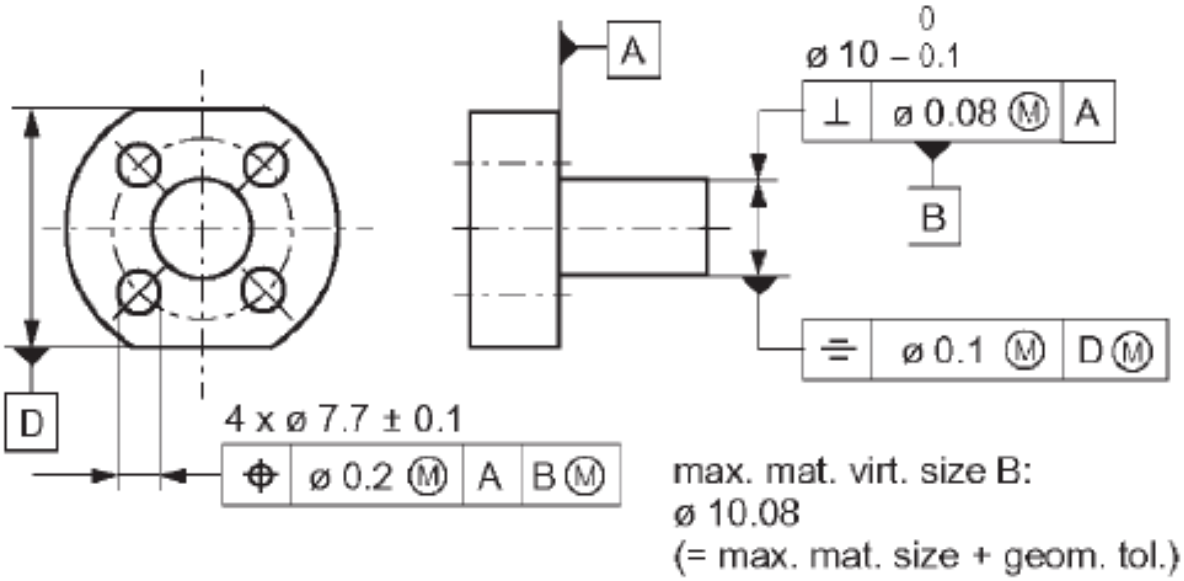


Fig. 9.5 Maximum material virtual size of datum B; perpendicularity tolerance to be regarded but symmetry tolerance to be disregarded

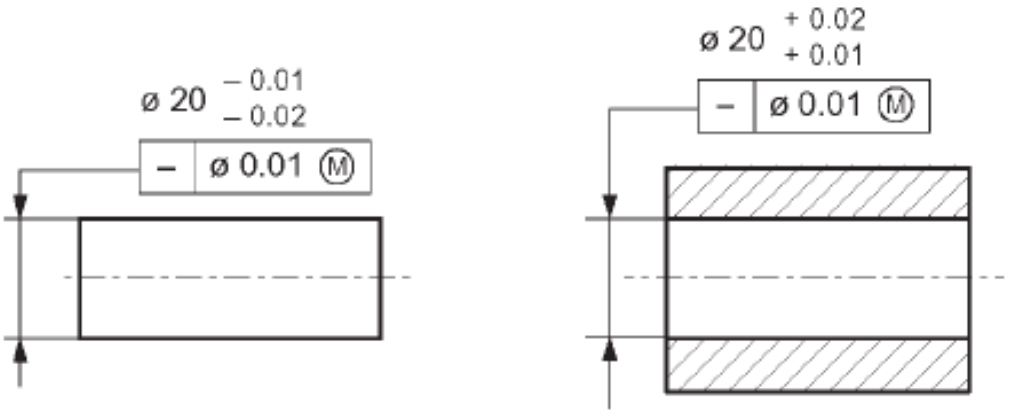


Fig. 9.6 Maximum material requirement applied to the straightness tolerance of the axis

Fig. 9.7 Gauge boundary for GD&T according to Fig. 9.6

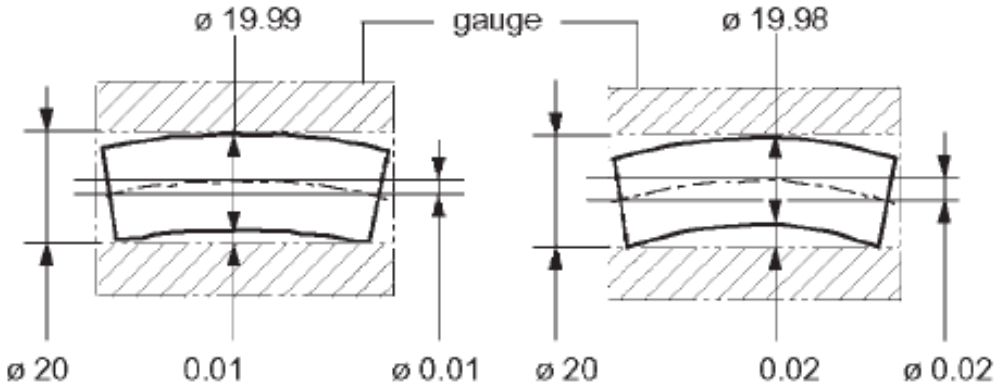


Fig. 9.8 Permissible extreme straightness deviations of the bolt according to Fig. 9.6

MMC: Application (5)

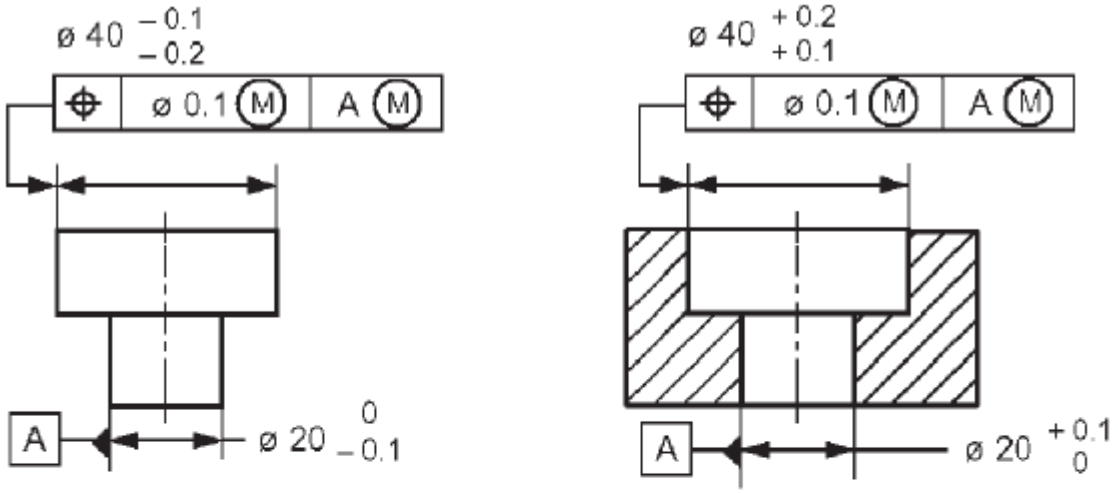


Fig. 9.9 Maximum material requirement for part and counterpart

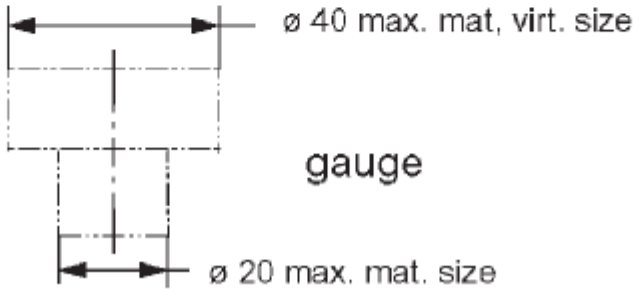
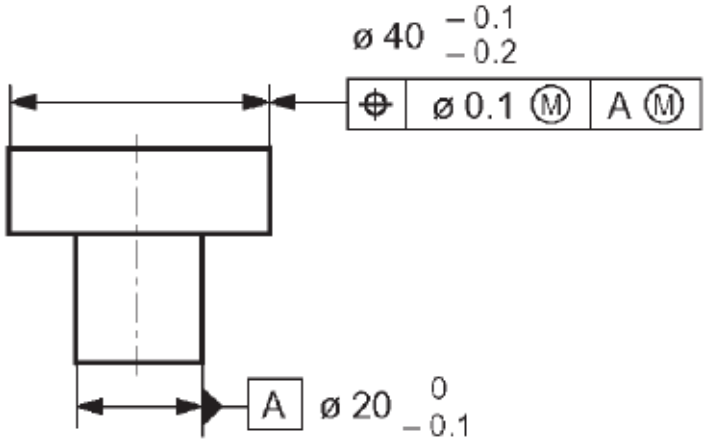


Fig. 9.10 Gauge for GD&T according to Fig. 9.9

MMC:



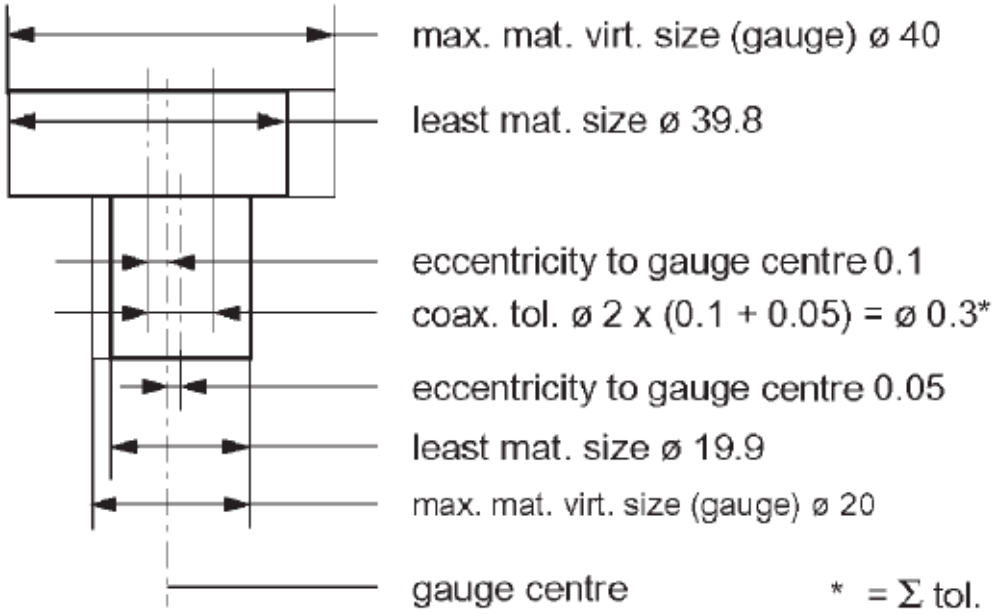


Fig. 9.11 Maximum material requirement and maximum possible coaxiality deviation

MMC: Applications (7)

- The symbol Ⓔ has been standardised because the drawing indication is simpler than with 0 Ⓜ and in order to avoid difficulties in interpretation.

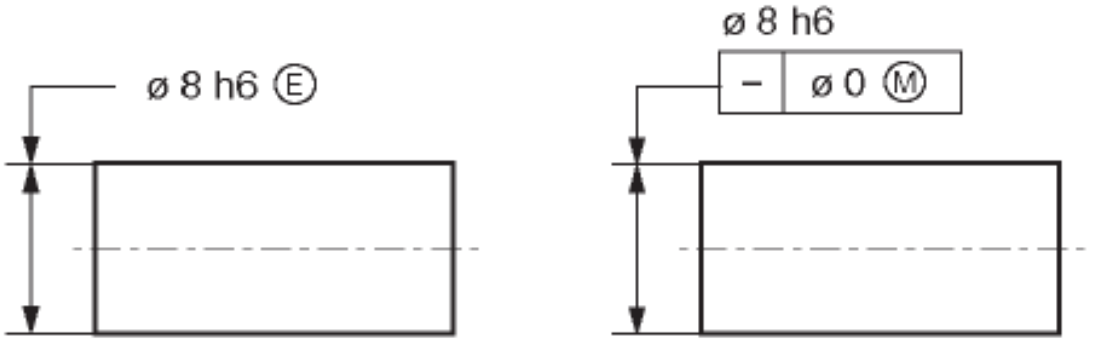


Fig. 9.17 Envelope requirement

Least Material Condition (LMC)

Definitions

- Least material condition (LMC): The state of the considered feature in which the feature is everywhere at that limit of size where the material of the feature is at its minimum.
- Least material virtual size (LMVS): Size of the least material size (LMS), the dimension defining the least material condition of a feature, and the geometrical tolerance followed by the symbol Ⓛ , i.e.
  - for shafts: LMVS = LMS - geometrical tolerance
  - for holes: LMVS = LMS + geometrical tolerance

LMC: Applications (1)

- A typical application is a casting when the final machined part shall be achievable.

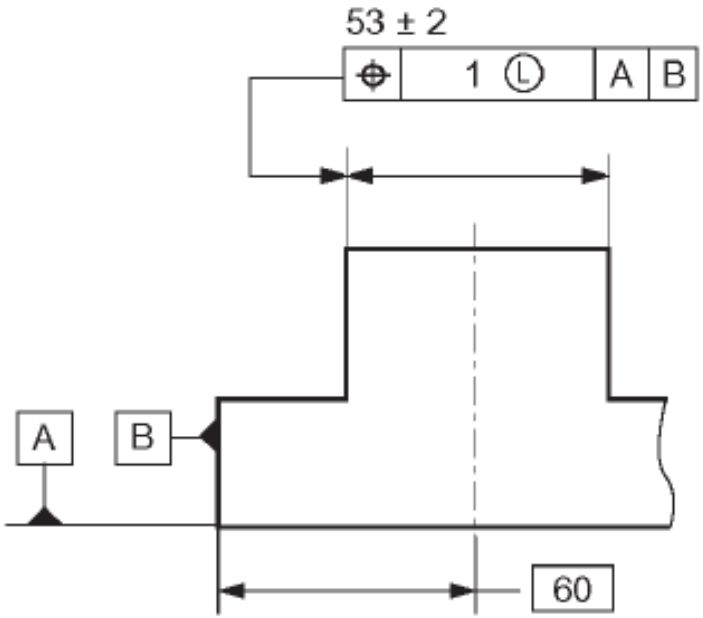


Fig. 11.1 Least material requirement

LMC: Applications (2)

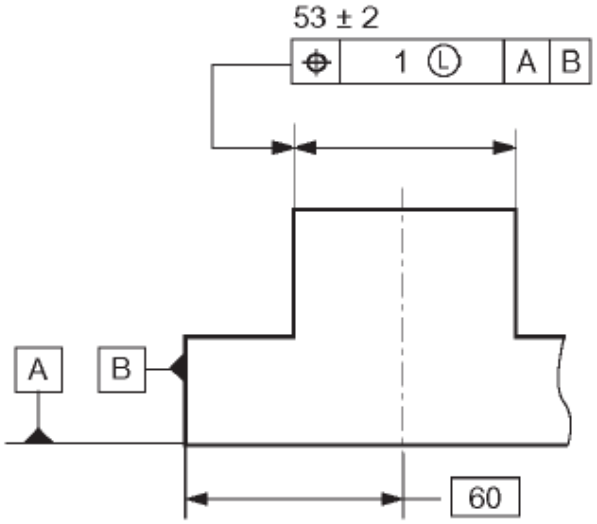


Fig. 11.1 Least material requirement

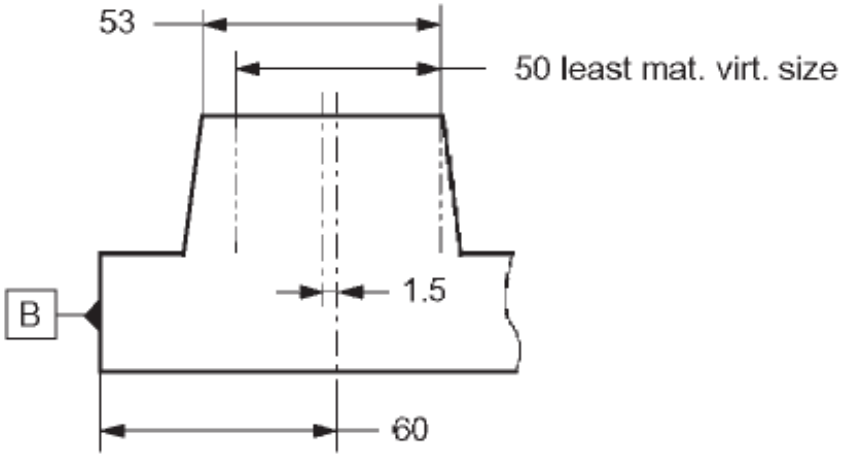


Fig. 11.2 Permissible workpiece according to the tolerancing in Fig. 11.1

LMC: Applications (3)

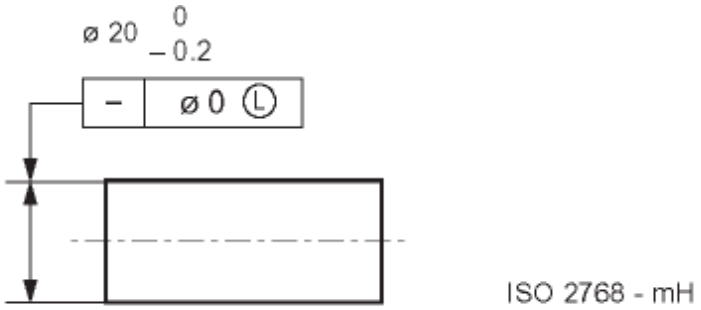


Fig. 11.3 Straightness tolerance of the axis with least material requirement

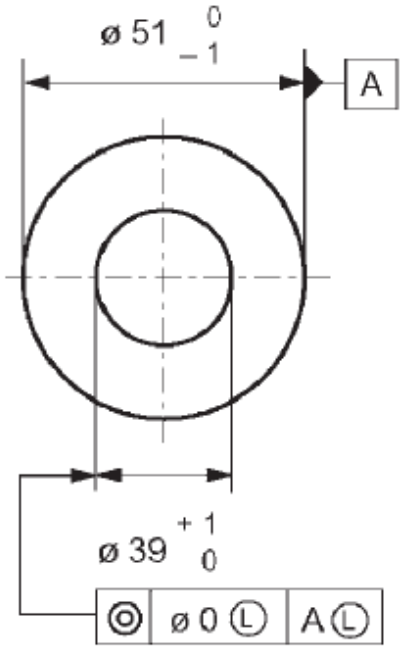


Fig. 11.5 Coaxiality tolerance with least material requirement in order to secure the minimum wall thickness

Regardless of Feature Size (RFS)

Definitions

- In previous revisions of the geometric tolerancing standard, the symbol for RFS was Ⓢ. This symbol is no longer used.
- If no material condition symbol is specified for the tolerance or datum reference, the feature automatically applies at RFS, which means that the tolerance is the same, no matter what size the feature has been produced within its limits of size.

RFS: Application

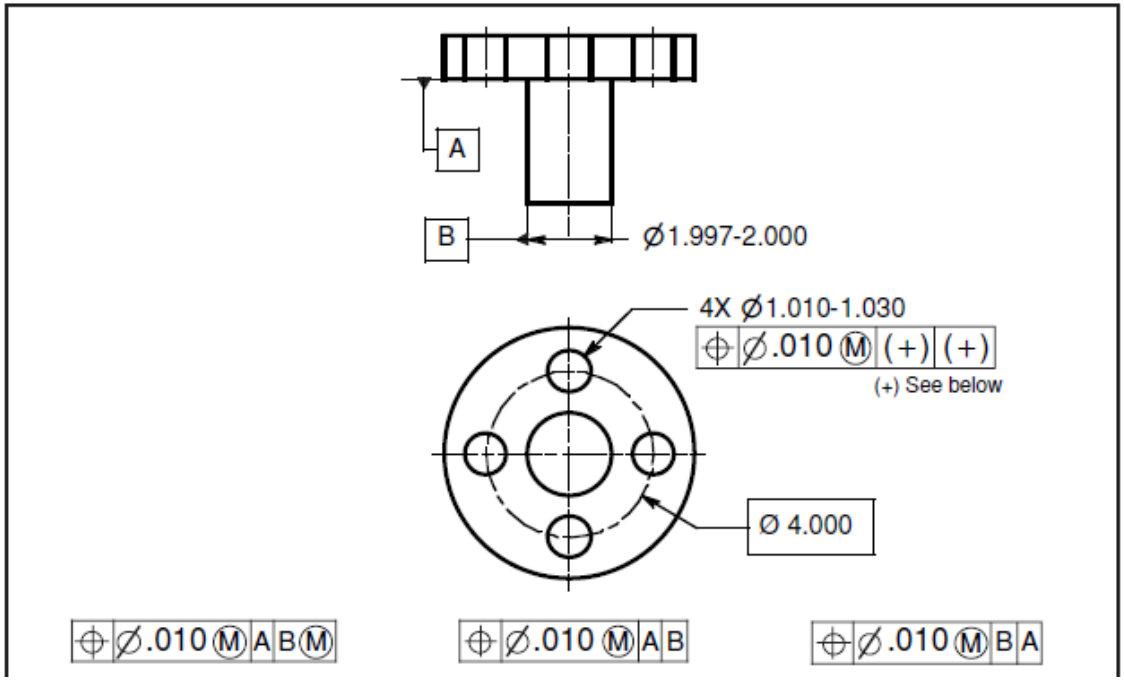


Figure 4-9 A datum feature of size specified at MMC, at RFS, and as primary and secondary datums. [10]

RFS: Application

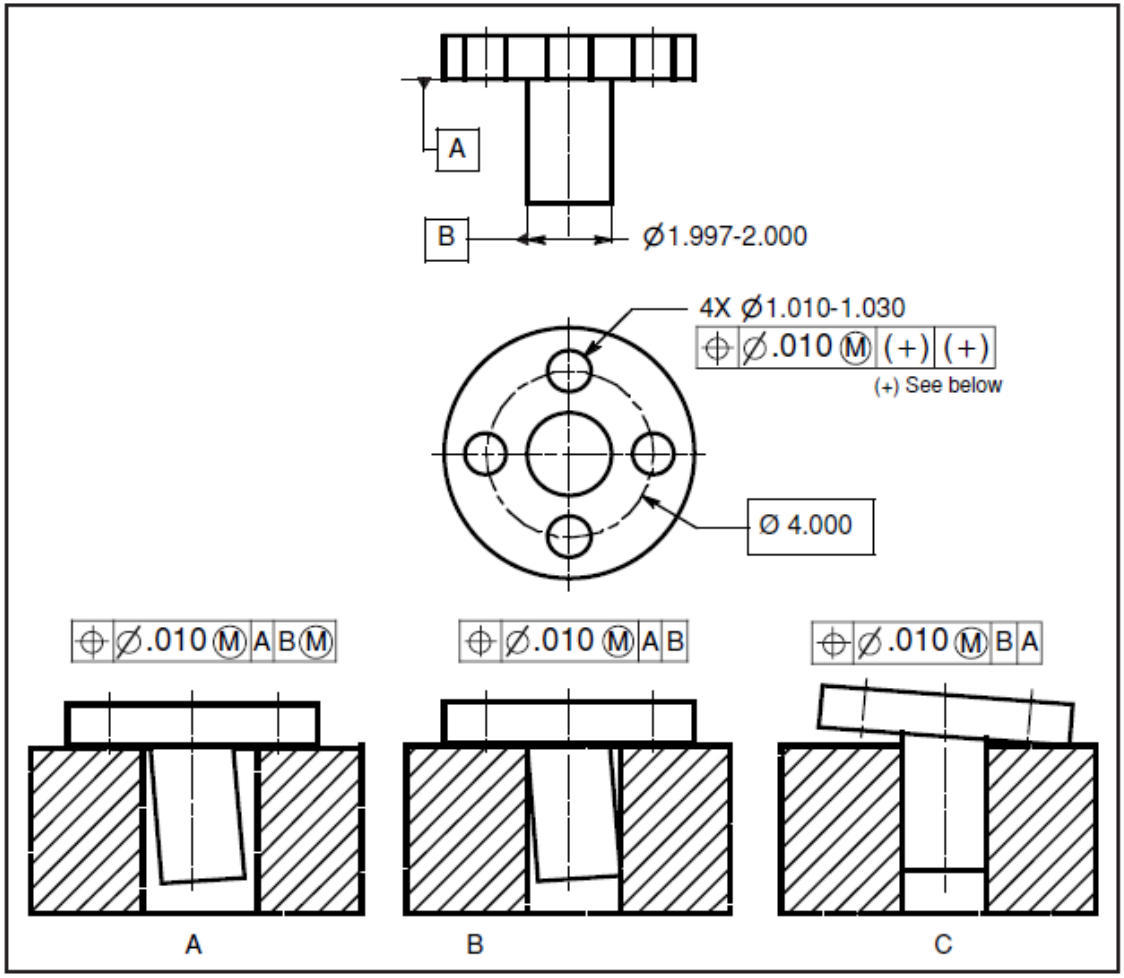


Figure 4-9 A datum feature of size specified at MMC, at RFS, and as primary and secondary datums. [10]

Reference Links/Books

[1] Geometrical Dimensioning and Tolerancing for Design, Manufacturing and Inspection (Georg Henzold)

[2] Mechanical Tolerance Stackup and Analysis (Bryan R. Fischer)

[3] Geometric Dimensioning and Tolerancing (James D. Meadows)

[4] www.engr.sjsu.edu

[5] www.engr.mun.ca

[6] engineering.armstrong.edu

[7] www.me.metu.edu.tr

[8] Dimensioning and Tolerancing Handbook (Paul J. Drake, Jr.)

[9] Geometric Dimensioning and Tolerancing (A. Krulikoski)

[10] Geometric Dimensioning and Tolerancing for Mechanical Design (Gene R. Cogorno)