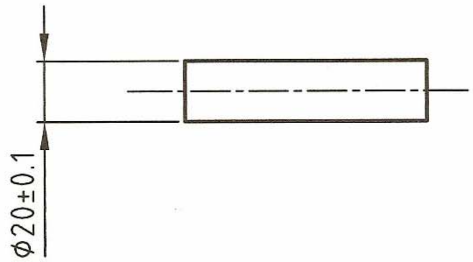
MAXIMUM MATERIAL CONDITION 12

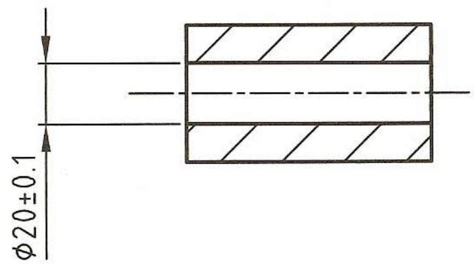
Maximum material condition (MMC) is the condition when a component or feature of a component has the maximum amount of material.

Example 1:
For a shaft, MMC would be when the diameter is everywhere at its maximum size.



MMC = when the shaft is Ø20.1 everywhere

For a hole, MMC is when its diameter is everywhere at its minimum size.



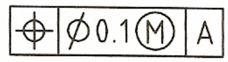
MMC = when the hole is Ø19.9 everywhere

Table 12.1 MMC related definitions

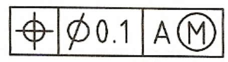
Definition	Abbreviation	Meaning
Maximum material condition	MMC	The state of a feature where the feature is everywhere at its maximum material
Maximum material size	MMS	The limit of size where the material of a feature is at its maximum. Shaft - maximum limit of size Hole - minimum limit of size
Maximum material virtual size	MMVS	The maximum material size plus or minus the geometrical tolerance. (for a shaft) MMVS=MMS + geometrical tolerance (for a hole) MMVS=MMS – geometrical tolerance
Maximum material requirement	MMR	When MMR is required on a drawing it is indicated on the drawing by placing the symbol Ⓜ in the tolerance frame either after the geometrical tolerance, after the datum letter or both

The Ⓜ symbol can be placed in the tolerance frame in the following ways:

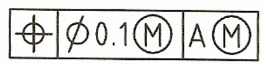
- after the tolerance value



- after the datum letter



- after the tolerance value and after the datum letter



Maximum Material Principle

The maximum material principle applies only to features with an AXIS or MEDIAN PLANE.

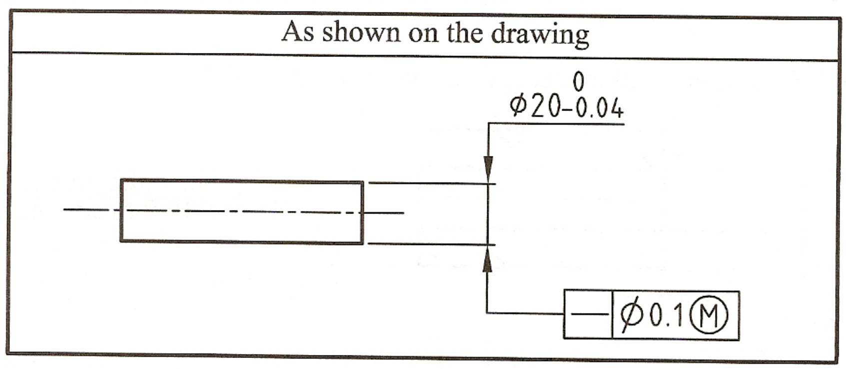


Figure 12.1 Example of applying maximum material principle

The actual measured diameter of the pin (figure 12.1) depicts the total increase in straightness tolerance. If the actual pin is Ø20 the allowed straightness tolerance is 0.1 but if the actual pin is Ø19.96 then the allowed straightness tolerance increases to 0.14 (this applies to all other sizes from Ø19.96 to Ø20). The straightness tolerance is allowed to increase from 0.1 to a maximum of 0.14 depending on the actual measured size of the pin (see table 12.2).

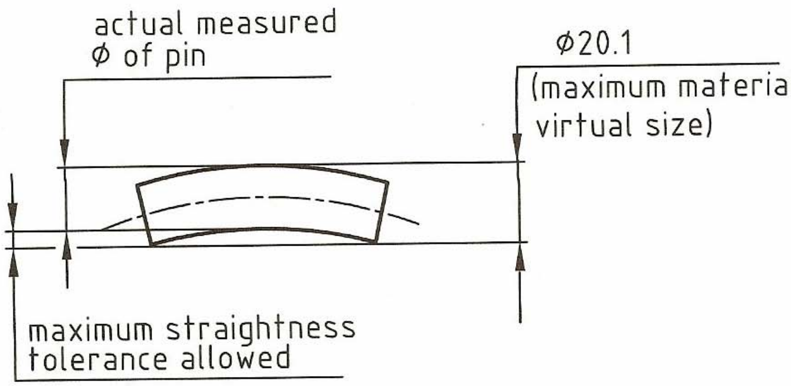
Table 12.2

Actual measured Ø of pin	Additional straightness tolerance allowed	Straightness tol. + Additional straightness tol. = Total geometrical tolerance allowed
20.00 Maximum material condition	0	0.1+ 0 = 0.1
19.99	0.01	0.1+ 0.01 = 0.11
19.98	0.02	0.1+ 0.02 = 0.12
19.97	0.03	0.1+ 0.03 = 0.13
19.96 Least material condition	0.04	0.1+ 0.04 = 0.14

Progressively increasing tolerance as the pin Ø decreases

Note:

Maximum material virtual size = Actual Ø of the measured pin + Maximum straightness tolerance allowed



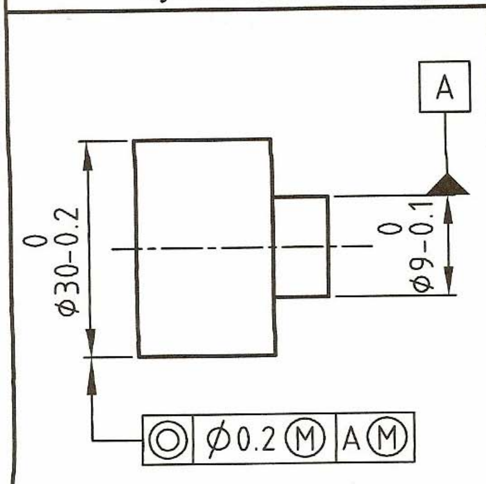
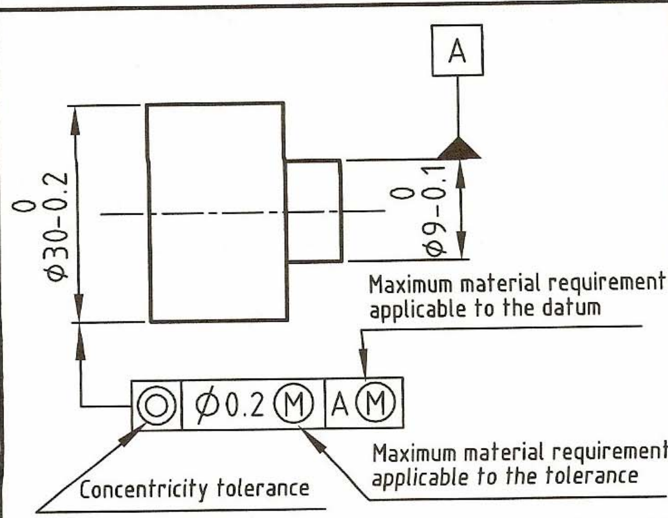
If the pin measures Ø19.97 then the maximum straightness tolerance allowed is 0.13 thus making the maximum material virtual size of Ø20.1

If the pin measures Ø19.99 then the maximum straightness tolerance allowed is 0.11 thus making the maximum material virtual size of Ø20.1

Maximum Material Principle Applied to Datum Features

This principle allows the DATUM AXIS or DATUM MEDIAN PLANE to float relative to the toleranced feature. Further addition to the stated tolerance in the feature frame can be achieved by applying MMR to the datum.

Example 2:

Symbol on the drawing	Interpretation
	

For example 2 the following scenarios could occur:

A. When $\phi 30^{\,0}_{-0.2}$ and $\phi 9^{\,0}_{-0.1}$ are both at their MMC (Ø30 and Ø9 respectively)

Total concentricity that is allowed	=	concentricity tolerance	+	any tolerance below MMC of Ø30	+	any tolerance below MMC of Ø9
0.2	=	0.2	+	0	+	0

B. When $\phi 30^{\,0}_{-0.2}$ is at MMC (Ø30) and $\phi 9^{\,0}_{-0.1}$ is at least limit of size (Ø8.9)

Total concentricity that is allowed	=	concentricity tolerance	+	any tolerance below MMC of Ø30	+	any tolerance below MMC of Ø9
0.3	=	0.2	+	0	+	0.1

C. When $\phi 30^{\,0}_{-0.2}$ and $\phi 9^{\,0}_{-0.1}$ are both at their least limit of size (Ø29.8 and Ø8.9 respectively)

Total concentricity that is allowed	=	concentricity tolerance	+	any tolerance below MMC of Ø30	+	any tolerance below MMC of Ø9
0.5	=	0.2	+	0.2	+	0.1

Maximum Material Condition (MMC) at Perfect Form

This is the condition when any errors of form are required to be contained within the maximum material limits of size. When the part is at its upper limit of size it is then assumed that the part is in perfect form.

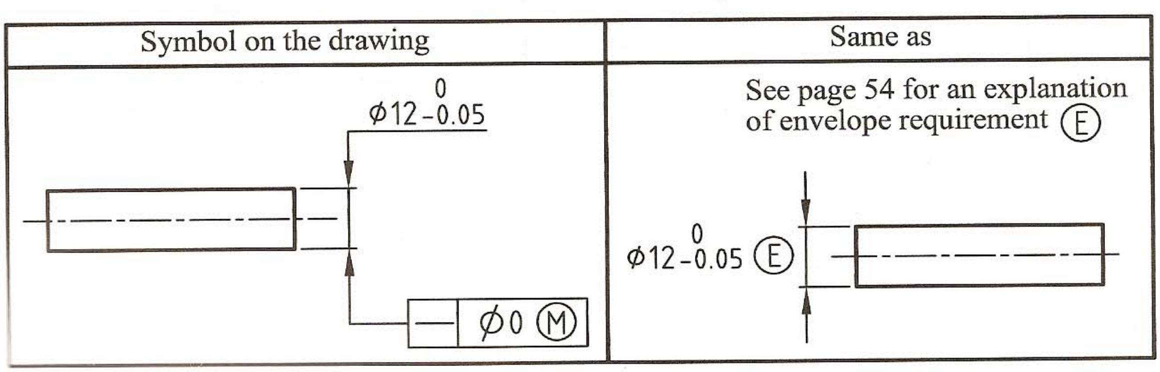
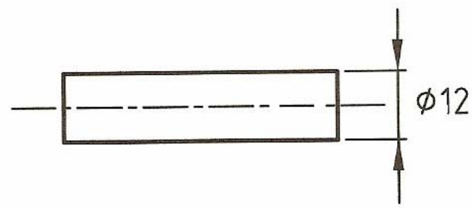
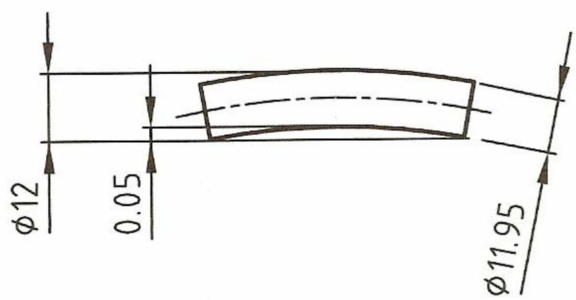


Figure 12.2 Example of applying maximum material condition at perfect form

When the pin in figure 12.2 is at its MMC Ø12 the pin must be perfectly straight



When the pin is at its lowest limit of size Ø11.95 the straightness tolerance can be 0.05



If the pin is at any dimension between Ø12 and Ø11.95 the straightness tolerance is adjusted accordingly i.e. at Ø11.97 the permitted straightness tolerance can be 0.03

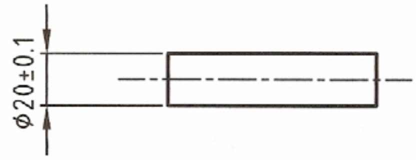
LEAST MATERIAL CONDITION 13

Least material condition (LMC) is the condition where the feature of size has the least amount of material within its size limits.

For a shaft, this is the minimum diameter
For a hole, this is the maximum diameter

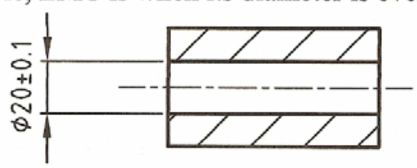
LMC can be used as an alternative to maximum material condition (MMC), it is a condition opposite to MMC.

Examples:
For a shaft, LMC would be when the diameter is everywhere at its minimum size.



LMC = when the shaft is Ø19.9 everywhere

For a hole, LMC is when its diameter is everywhere at its maximum size.



LMC = when the hole is Ø20.1 everywhere

The Ⓛ symbol can be placed in the tolerance frame in the following ways:
after the tolerance value [⌖ | ϕ0.1Ⓛ | A], after the datum letter [⌖ | ϕ0.1 | AⓁ], or
after the tolerance value and after the datum letter [⌖ | ϕ0.1Ⓛ | AⓁ]

Table 13.1 LMC related definitions

Definition	Abbreviation	Meaning
Least material condition	LMC	The state of a feature where the feature is everywhere at its minimum material
Least material size	LMS	The limit of size where the material of a feature is at its minimum. Shaft - minimum limit of size Hole - maximum limit of size
Least material virtual size	LMVS	The minimum material size plus or minus the geometrical tolerance. (for a shaft) LMVS=LMS – geometrical tolerance (for a hole) LMVS=LMS + geometrical tolerance
Least material requirement	LMR	When LMR is required on a drawing it is indicated on the drawing by placing the symbol Ⓛ in the tolerance frame either after the geometrical tolerance, after the datum letter or both

Least material principle allows the datum axis (or datum median plane) to float relative to the toleranced feature when leaving least material condition and approaching maximum material condition.
The surface of the datum feature must not violate the least material virtual condition (geometrical ideal form and of least material virtual size).

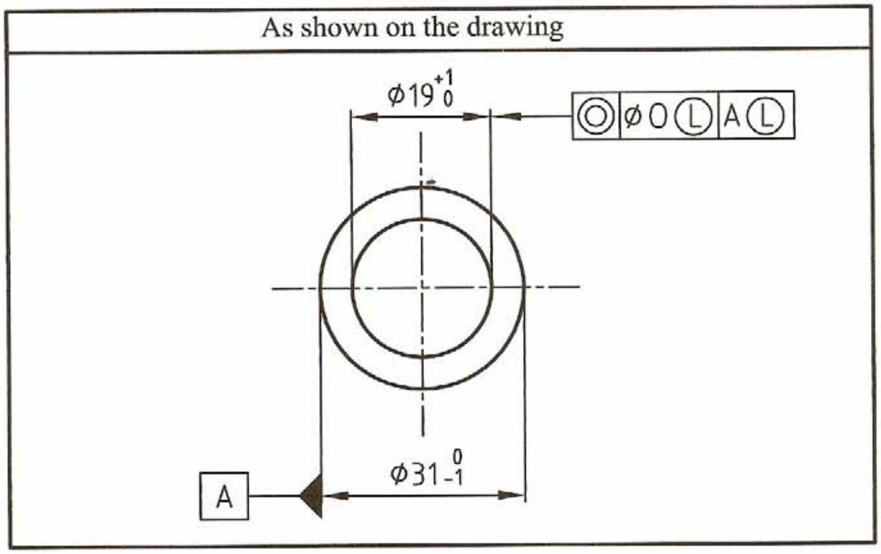


Figure 13.1 Example of applying least material principle

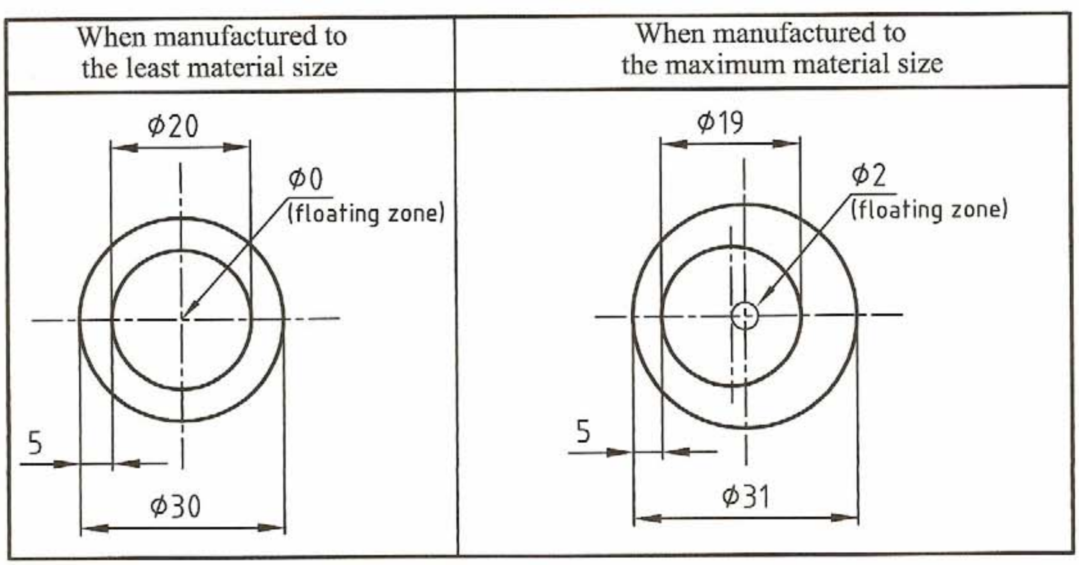


Figure 13.2

Note:
In the example figure 13.1 above, the minimum wall thickness of 5mm for the tube has been achieved when the piece has been manufactured to either the least material size OR the maximum material size.