GEOMETRIC DIMENSIONING

FACTS TO REMEMBER

Ⓜ – MMC – MAXIMUM MATERIAL CONDITION: THAT CONDITION WHERE A FEATURE OF SIZE CONTAINS THE MAXIMUM AMOUNT OF MATERIAL WITHIN THE STATED LIMITS OF SIZE. EXAMPLE: MINIMUM HOLE SIZE AND MAXIMUM SHAFT SIZE.

Ⓛ – LMC – LEAST MATERIAL CONDITION: THAT CONDITION WHERE A FEATURE OF SIZE CONTAINS THE LEAST AMOUNT OF MATERIAL WITHIN THE STATED LIMITS OF SIZE. EXAMPLE: MAXIMUM HOLE SIZE AND MINIMUM SHAFT SIZE.

RFS – REGARDLESS OF FEATURE SIZE: THIS IS THE DEFAULT CONDITION FOR ALL GEOMETRIC TOLERANCES. NO BONUS TOLERANCES ARE ALLOWED. FUNCTIONAL GAGES MAY NOT BE USED.

Ⓟ – PROJECTED TOLERANCE ZONE: WHEN THE SYMBOL IS SHOWN, IT MEANS THE STATED TOLERANCE ZONE IS EXTENDED BEYOND THE SURFACE OF THE PART, NOT WITHIN THE PART.

(ST) – STATISTICAL TOLERANCE: A TOLERANCE FOR A PART OF AN ASSEMBLY BASED ON THE RESULTS FROM A STATISTICAL CALCULATION. THE DESIRED RESULT IS LARGER TOLERANCES.

Ⓕ – FREE STATE: THIS SYMBOL INDICATES THE PARTS MUST NOT BE RESTRICTED DURING INSPECTION.

[A] – DATUM SYMBOL: THIS SYMBOL IS ATTACHED TO A PLANE OR SIZE FEATURE THAT MUST BE CONTACTED FOR MACHINING AND INSPECTION.

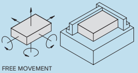
[XXX] – BASIC DIMENSION: THESE DIMENSIONS HAVE NO TOLERANCE. THEY ONLY LOCATE A TOLERANCE ZONE.

Ø – DIAMETER SYMBOL: THIS SYMBOL REPLACES THE WORD "DIAMETER." IT SHOULD BE USED ANYWHERE THERE IS A DIAMETER ON THE DRAWING, AND WHEN A TOLERANCE ZONE IS CYLINDRICAL.

TOLERANCE ZONES: ALL TOLERANCE ZONES SHOWN IN THE FEATURE CONTROL FRAME ARE TOTAL. EXAMPLE: FLATNESS WITHIN .004 MEANS THAT TWO PARALLEL PLANES NO MORE THAN .004 APART DEFINE THE TOLERANCE ZONE.

(A1) – DATUM TARGETS: USED TO LO SPECIFIC POINTS, LINES, OR ARE ON PARTS USED FOR SUPPORT MACHINING AND INSPECTION COMMONLY USED ON RIGID PARTS LIKE CASTINGS AND FORGINGS AND NON-RIGID PARTS MADE FROM PLASTIC, RUBBER, OR SHEET METAL.

DATUM REFERENCE FRAME: (THREE PLANE CONCEPT). THE CONCEPT OF USING MUTUALLY PERPENDICULAR FEATURES OF A PART TO CONTROL ITS FREE MOVEMENT IN SPACE (DEGREES OF FREEDOM). SEE DATUM SYMBOL AND DATUM TARGETS.



FREE MOVEMENT

RESTRICTED MOVEMENT

LIMITS OF SIZE RULE: WHERE ONLY A SIZE DIMENSION IS GIVEN. a) THE SIZE DIMENSIONS AT ANY CROSS SECTION MUST BE WITHIN THE SIZE TOLERANCE. b) THE SURFACE(S) SHALL NOT EXTEND BEYOND THE PERFECT FORM DEFINED BY THE MMC SIZE. c) THE FORM MAY VARY WITHIN AN ENVELOPE BETWEEN THE MMC AND LMC.

GEOMETRIC TOLERANCE RULE: GEOMETRIC TOLERANCES ARE UNDERSTOOD TO BE APPLIED RFS. IF MMC OR LMC IS REQUIRED, IT MUST BE PLACED IN THE FEATURE CONTROL FRAME. SEE MMC, LMC, OR RFS COLUMN.

PITCH DIAMETER RULE: TOLERANCES THAT APPLY TO SCREW THREADS APPLY TO THE AXIS OF THE THREAD DERIVED FROM THE PITCH CYLINDER. IF ANOTHER PART OF THREAD IS TO BE USED TO DERIVE THE AXIS, IT MUST BE STATED BENEATH THE FEATURE CONTROL FRAME. ANY OTHER FEATURE THAT HAS A PITCH DIAMETER MUST HAVE THE DATUM FEATURE STATED.

SYMBOLS, RULES, AND GUIDELINES

TYPE	SYMBOL	AS SHOWN ON DRAWING	TOLERANCE ZONE	MMC LMC OR RFS	DATUM USED	FUNC GAGE USED	TOLER ZONE TYPE
FORM	— STRAIGHTNESS	Ø .500 ± .005; — .004	TWO PARALLEL LINES .004 APART	Ⓜ OR Ⓛ CAN APPLY TO A FEATURE OF SIZE.	NO	YES IF Ⓜ IS STATED	Ⓐ Ⓗ Ⓙ
FORM	▱ FLATNESS	□ .500 ± .005; ▱ .004	TWO PARALLEL PLANES, .004 APART	DOES NOT APPLY	NO	NO	Ⓓ
FORM	○ CIRCULARITY	Ø .500 ± .005; ○ .004	TWO CONCENTRIC CIRCLES .004 APART	DOES NOT APPLY	NO	NO	Ⓑ
FORM	⌭ CYLINDRICITY	Ø .500 ± .005; ⌭ .004	TWO CONCENTRIC CYLINDERS .004 APART	DOES NOT APPLY	NO	NO	Ⓔ
ORIENTATION	// PARALLELISM	// .004 A; A	TWO PARALLEL PLANES.004 APART; A	Ⓜ OR Ⓛ CAN APPLY TO A FEATURE OF SIZE.	YES	YES IF Ⓜ IS STATED	Ⓐ Ⓓ Ⓖ Ⓗ Ⓙ
ORIENTATION	⊥ PERPEN–DICULARITY	⊥ .004 A; A	TWO PARAL–LEL PLANES .004 APART; 90°; A	Ⓜ OR Ⓛ CAN APPLY TO A FEATURE OF SIZE.	YES	YES IF Ⓜ IS STATED	Ⓐ Ⓓ Ⓖ Ⓗ Ⓙ
ORIENTATION	∠ ANGULARITY	∠ .004 A; 15°; A	TWO PARALLEL PLANES .004 APART; 15°; A	Ⓜ OR Ⓛ CAN APPLY TO A FEATURE OF SIZE.	YES	YES IF Ⓜ IS STATED	Ⓐ Ⓓ Ⓖ Ⓗ Ⓙ
PROFILE	⌒ PROFILE OF A LINE	⌒ .004	TWO LINES .004 APART ALONG TRUE PROFILE	DOES NOT APPLY	MAY BE USED OR MAY NOT	NO	Ⓒ
PROFILE	⌓ PROFILE OF A SURFACE	⌓ .004 A; A	TWO PLANES .004 APART ALONG TRUE PROFILE; A	DOES NOT APPLY	MAY BE USED OR MAY NOT	NO	Ⓓ Ⓔ Ⓕ
RUNOUT	↗ CIRCULAR RUNOUT	↗ .004 A; A; XX	CONCENTRIC CIRCLES .004 APART; A; XX	RFS ALWAYS	YES	NO	Ⓑ
RUNOUT	⌰ TOTAL RUNOUT	⌰ .004 A; A; XX	TWO CONCENTRIC CYLINDERS .004 APART; A; XX	RFS ALWAYS	YES	NO	Ⓔ
LOCATION	⌖ POSITION	Ø .250 ± .004; ⌖ Ø.014 Ⓜ A B C; B; .380; A; .620; C	Ø .022 ZONE AT LMC; Ø .014 ZONE AT MMC; .620; .380; TRUE CENTER	Ⓜ OR Ⓛ CAN APPLY TO A FEATURE OF SIZE.	YES	YES IF Ⓜ IS STATED	Ⓖ Ⓗ Ⓙ
LOCATION	◎ CONCEN–TRICITY	◎ Ø .004 A; A; XX	Ø .004 AROUND DATUM AXIS; XX; A	RFS ALWAYS	YES	NO	Ⓙ
LOCATION	⌯ SYMMETRY	A; XX; ⌯ .004 A	A; XX; .004 EQUALLY DISPOSED FROM CENTER PLANE	RFS ALWAYS	YES	NO	Ⓖ Ⓗ

FACTS TO REMEMBER

FEATURE CONTROL FRAME:

⌖ | Ø .005 Ⓜ | A | B | C

- TERTIARY DATUM (ONE POINT MIN)
- SECONDARY DATUM (TWO POINTS MIN)
- PRIMARY DATUM (THREE POINTS MIN)
- MODIFIER FOR THE STATED TOLERANCE
- STATED TOLERANCE
- DIAMETER SYMBOL (CYLINDRICAL TOLERANCE ZONE)
- GEOMETRIC CHARACTERISTIC SYMBOL

BASIC SENTENCE STRUCTURE: WHEN USING THE ENGLISH LANGUAGE TO SAY WHAT IS IN THE FEATURE CONTROL FRAME. YOU MAY USE THE FOLLOWING CONNECTING WORDS:

⌖ | Ø .005 Ⓜ | A | B | C

WITHIN — RELATIVE TO

EXAMPLE: THE POSITION OF THE FEATURE AXIS MUST BE *WITHIN* A .005 TOLERANCE ZONE AT MMC *RELATIVE* TO DATUM FEATURES A, B, AND C.

BONUS TOLERANCE: WHEN MMC IS SHOWN MODIFYING A FEATURE, THE STATED TOLERANCE APPLIES ONLY WHEN THE FEATURE BEING CONTROLLED IS AT MMC. THE BONUS IS THE DIFFERENCE BETWEEN THE ACTUAL SIZE AND THE MMC SIZE AND MAY BE ADDED DIRECTLY TO THE ORIGINAL TOLERANCE.

EXAMPLE:

Ø .500 – .507

⌖ | Ø .005 Ⓜ | A

ACTUAL = .503
– MMC = .500
BONUS = .003

AT MMC THE HOLE MUST BE POSITIONED WITHIN A CYLINDRICAL TOLERANCE ZONE OF .005 DIAMETER. AS THE EXAMPLE SHOWS, THE HOLE HAS DEPARTED FROM MMC BY .003. THE .003 BONUS TOLERANCE MAY NOW BE ADDED TO THE ORIGINAL .005 ZONE FOR A TOTAL OF .008 TOLERANCE.

FUNCTIONAL GAGES: DEVICES THAT MEASURE THE COLLECTIVE EFFECTS OF SIZE AND GEOMETRIC TOLERANCES AT THE SAME TIME. IT REPRESENTS A SIMULATED MATING CONDITION.

BONUS TOLERANCES AND FUNCTIONAL GAGES: DIRECTLY APPLICABLE TO ANY GEOMETRIC TOLERANCE THAT IS MODIFIED BY Ⓜ.

SHIFT: AS A DATUM FEATURE OF SIZE, THAT IS GEOMETRICALLY CONTROLLED, DEPARTS FROM MMC, ADDITIONAL TOLERANCE MAY BE CONSIDERED FOR THE CONTROLLED FEATURES. THIS ADDITIONAL TOLERANCE DOES NOT ADD DIRECTLY TO THE ORIGINAL TOLERANCE BUT MUST BE APPLIED TO THE PATTERN OF FEATURES AS A GROUP. IT IS CONSIDERED A TOLERANCE THAT ALLOWS THE CONTROLLED FEATURES TO SHIFT AS A GROUP.

VIRTUAL CONDITION: THE COLLECTIVE EFFECT OF SIZE AND GEOMETRIC TOLERANCES THAT MUST BE CONSIDERED IN DETERMINING THE FIT OR CLEARANCE BETWEEN MATING PARTS OR FEATURES.

TO CALCULATE VIRTUAL CONDITION:

EXTERNAL FEATURES:
MMC SIZE + TOLERANCE OF FORM, ORIENTATION, OR LOCATION

INTERNAL FEATURES:
MMC SIZE – TOLERANCE OF FORM, ORIENTATION, OR LOCATION

A VIRTUAL CONDITION WILL EXIST ONLY FOR TOLERANCES THAT CONTROL SIZE FEATURES.

* THIS COLUMN INDICATES POSSIBLE TOLERANCE ZONES THAT MAY BE USED WITH THE VARIOUS CONTROLS. THE DIFFERENT TOLERANCE ZONES ARE SHOWN ALONG THE BOTTOM OF THIS CHART.

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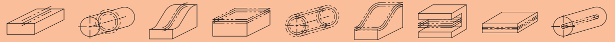
GENIUM PUBLISHING CORP.
ONE GENIUM PLAZA
SCHENECTADY, NY 12304
(518) 377-8854



Ⓐ PARALLEL LINES — Ⓑ PARALLEL LINES — Ⓒ PARALLEL LINES — Ⓓ PARALLEL PLANES — Ⓔ PARALLEL PLANES — Ⓕ PARALLEL PLANES — Ⓖ PARALLEL PLANES — Ⓗ PARALLEL PLANES — Ⓙ CYLINDER ZONE