APPENDIX

CONVERSION FACTORS

LENGTH

1m = 10^3 mm = 10^2 cm = 10^{-3} kilometre = 10^6 microns = 10^9 nanometres = 10^{10} Angstrom (Å) = 10^{16} fermi = 39.37 in = 3.28 ft = 1.094 yd.

1 cm = 10^4 microns = 10^7 nanometers = 10^8 Å

1 inch = 25.4 mm = 2.54 cm = 0.0254 m = 1000 mil (1 mil = 0.001 in)

1 micron (μ) = 1 μm = 10^{-6} metre = 10^{-3} millimeter.

FORCE

1 N (newton) = 10^{-3} sthene = 10^5 dynes = 0.102 kgf = 0.225 lbf.

1 lbf = 0.454 kgf = 454 gf = 4.45 N = 4.45×10^5 dyne.

1 dyne = 10^{-5} N = 0.102×10^{-5} kgf = 0.225×10^{-5} lbf.

1 kgf = 10^3 gf = 221 lbf = 9.81 N = 9.81×10^5 dyne = 10^{-3} tonne force.

STRESS : PRESSURE

1 N/m^2 = 1 pascal (pa) = 1.02 kgf/mm^2 = 1.45×10^{-4} psi = 10 dyne/cm

1 kgf/mm^2 = 9.81×10^6 N/m^2 = 1.426×10^3 psi = 9.81×10^7 $dyne/cm^2$

1 psi = 6.89×10^3 N/m^2 = 7.02×10^{-4} kgf/mm^2 = 6.89×10^4 $dyne/cm^2$

1 atm = 760 mm of Hg = 1.01×10^5 N/m^2 = 1.03×10^{-2} kgf/mm^2

WORK AND ENERGY

1 Joule (J) = 1 N.m = 1 W.s = 10^7 erg = 0.239 cal = 0.625×10^{12} eV

1 eV/molecule = 1.602×10^{-19} J = 1.602×10^{-12} erg = 23×10^3 cal/mol

1 cal = 4.18 J = 4.18×10^7 erg = 2.62×10^{19} eV

1 erg = 10^{-7} J = 0.239×10^{-7} cal = 0.625×10^{19} eV

1 hph = 27×10^4 kgfm = 632 kcal = 2.65×10^6 J

1 kWh = 3671×10^2 kgfm = 860 kcal = 3.6 MJ

1 kgfm = 9.81 J

SPECIFIC HEAT CAPACITY

1 J/kg K = 10^4 erg/g °C = 0.239×10^{-3} kcal/kg °C

1 kcal/kg °C = 1 cal/g °C = 4.19×10^7 erg/g °C = 4.19×10^3 J/kg K

1 J/m^3 K = 0.239×10^{-3} $kcal/m^3$ °C

OTHERS

1 gauss = 10^{-4} $weber/m^2$ = 10^{-4} tesla (T)

1debye = 0.33×10^{-29} coul.m

1 oersted = 76.6 amp-turn/m

1 gauss/oersted = 79.6×10^{-4} henry/m

Tolerance grade and surface roughness for different manufacturing processes

Manufacturing Processes	*IT grade*	*Surface roughness in microns*
1. Lapping	4 and 5	0.012 to 0.016
2. Honing	4 and 5	0.025 to 0.40
3. Cylindrical grinding	5 to 7	0.063 to 5
4. Surface grinding	5 to 8	0.063 to 5
5. Broaching	5 to 8	0.40 to 3.2
6. Reaming	6 to 10	0.40 to 3.2
7. Turning	7 to 13	0.32 to 25
8. Hot rolling	8 to 10	2.5 to 50
9. Extrusion	8 to 10	0.16 to 5
10. Boring	8 to 13	0.4 to 6.3
11. Milling	10 to 13	0.32 to 25
12. Planing and shaping	10 to 13	1.6 to 25
13. Drilling	10 to 13	1.6 to 25
14. Die casting	12 ro 14	5 to 50
15. Sand casting	14 to 16	0.80 to 3.20
16. Forging	14 to 16	1.60 to 2.5

M CODES FOR MILLING

M code	*Function*
M00	Programme stop
M01	Optional programme stop
M02	End of program (rewind tape)
M03	Spindle on (clock wise)
M04	Spindle on (counterclockwise)
M05	Spindle stop
M06	Program stop (manual tool change)
M08	Coolant on
M09	Coolant off
M13	Spindle on clockwise/coolant on
M14	Spindle on counterclockwise/coolant on
M17	Spindle off/coolant off
M19	Oriented spindle stop
M21	Mirror imaging about the X axis
M22	Mirror imaging about the Y axis
M23	Mirror image cancel
M30	Program end/memory reset
M41	Low-gear range for spindle
M42	High-gear range for spindle
M48	Override cancel off
M49	Override cancel on
M98	Transfer control to a subroutine
M99	Return from a subroutine

G CODES FOR MILLING OPERATIONS

G code	*Function*	*Mode*
G00	Rapid positioning (traverse tool movement)	Modal
G01	Linear interpretation (tool movement at feed rate)	Modal
G02	Circular interpolation clockwise (CW)	Modal
G03	Circular interpolation counterclockwise (CCW)	Modal
G04	Programmed dwell	Nonmodal
G09	Exact stop	Nonmodal
G10	Offset value for tool length	Nonmodal
G17	Plane selection X, Y	Modal
G18	Plane selection X, Z	Modal
G19	Plane selection Y, Z	Modal
G20	Input data in inches	Modal
G21	Input data in metric (mm)	Modal
G22	Programmed safety zone (no tool entry)	Modal
G23	Tool entry of programmed safety zone	Modal
G28	Return to reference point	Nonmodal
G29	Return from reference point	Nonmodal
G30	Return to second, third, and fourth reference point	Nonmodal
G33	Thread cutting autocycle	Modal
G40	Cancel cutter diameter compensation	Modal
G41	Cutter diameter compensation left	Modal
G42	Cutter diameter compensation right	Modal
G43	Tool length compensation (positive direction)	Modal
G44	Tool length compensation (negative direction)	Modal
G45	Tool offset increase	Nonmodal
G46	Tool offset decrease	Nonmodal
G47	Tool offset double increase	Nonmodal
G48	Tool offset double decrease	Nonmodal
G49	Cancel tool length compensation	Modal
G50	Scaling off	Modal
G51	Scaling on	Modal
G65	Call user macro (one-time call)	Nonmodal
G66	Call user macro (repeat call)	Modal
G67	Cancel G66 function	Modal
G73	Peck drilling autocycle	Modal
G74	Counter tapping autocycle	Modal
G76	Fine boring autocycle	Modal
G80	Cancel any fixed cycles	Modal
G81	Drilling autocycle	Modal
G82	Counterboring autocycle	Modal
G83	Peck drilling autocycle	Modal
G84	Tapping autocycle	Modal
G85	Boring autocycle (return to reference level at feed)	Modal
G86	Boring autocycle (return to reference level at rapid)	Modal
G87	Back boring autocycle	Modal
G88	Boring cycle (manual return to reference level)	Modal
G89	Boring cycle (dwell, then return to reference at feed)	Modal
G90	Absolute programming mode	Modal
G91	Incremental programming mode	Modal
G92	Zero offset (programming of temporary zero point)	Nonmodal
G94	Per minute feed programming	Modal
G95	Per revolution feed programming	Modal
G98	Return to initial point in autocycle	Modal
G99	Return to R plane in autocycle	Modal

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