TOLERANCING

➢ Dimensioning is a means of communicating size and location information on and engineering drawing.

➢ Tolerancing can be thought of as a way of controlling variations in dimension values on a drawing.

➢ This translates to controlling variations in parts, leading to standardization; a crucial requirement of interchangeability in parts.

➢ Tolerances are established based on a number of factors including; standards, accepted practices, and most importantly, the functionality of the part.

➢ Tolerances must be specified in such a way that a product functions as it should at a cost that is reasonable.

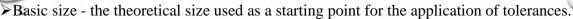➢ Position tolerances control position dimensions and Form tolerances control mainly size dimensions

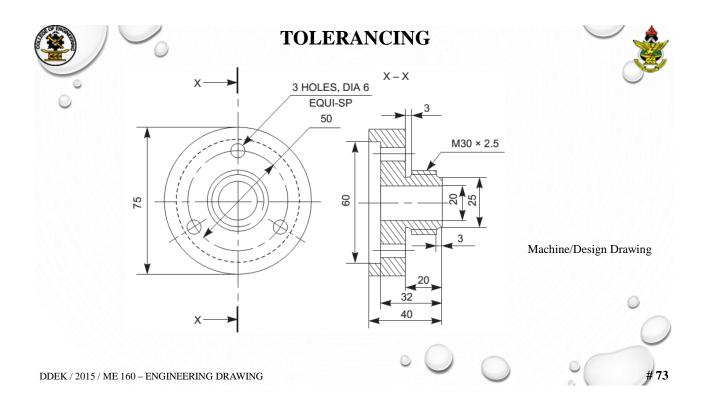DDEK / 2015 / ME 160 – ENGINEERING DRAWING   **# 71**

TOLERANCING
Some Terms

➢ Basic size - the theoretical size used as a starting point for the application of tolerances.

➢ Actual size - the measured size of the finished part after machining.

➢ Limits - the maximum and minimum sizes shown by the toleranced dimension.

➢ Least material condition (LMC) - the condition of a part when it contains the least amount of material possible.

➢ Maximum material condition (MMC) – opposite of LMC.

➢ Piece tolerance - the difference between the upper and lower limits of a single part

➢ System tolerance - the sum of all the piece tolerances.

➢ Datum - Planes, lines or points from which other features are located (will be seen in geometric tolerancing)

➢ Nominal size – a dimension used to describe the general size.

DDEK / 2015 / ME 160 – ENGINEERING DRAWING   **# 72**
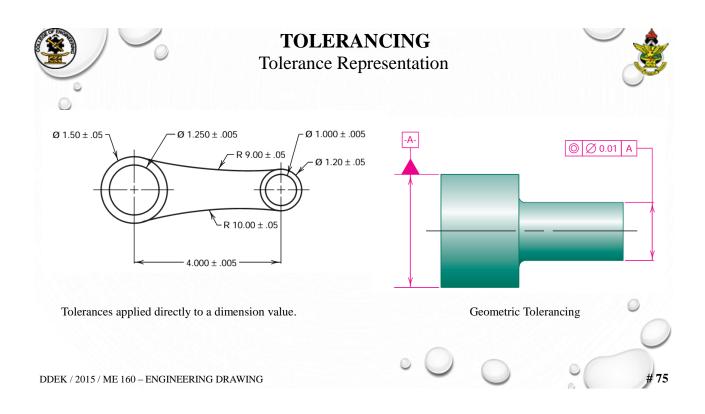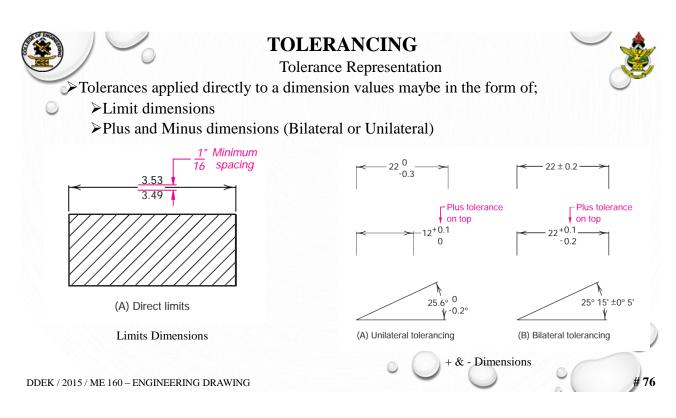
TOLERANCING

Machine/Design Drawing

TOLERANCING
Tolerance Representation

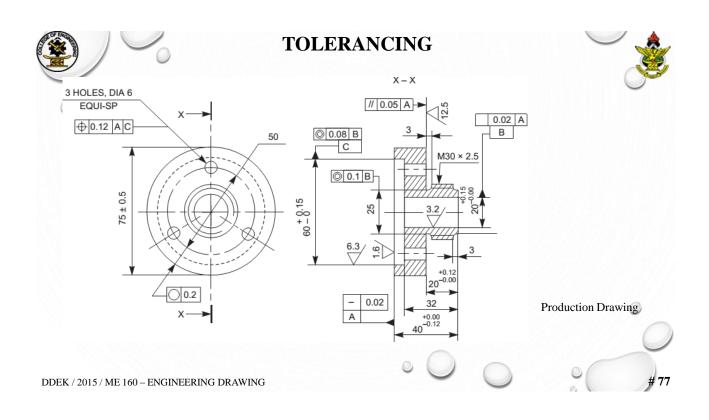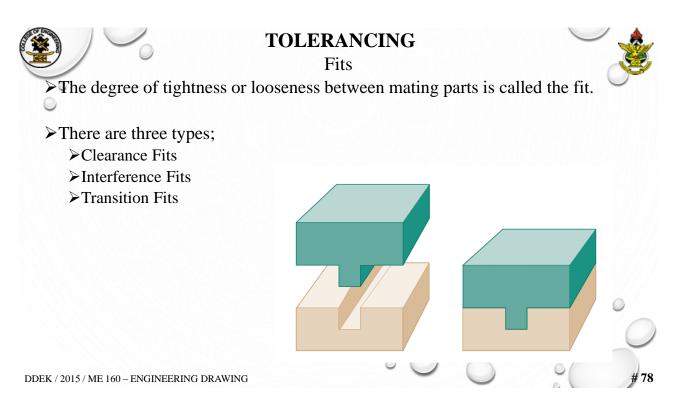➢Tolerances may be applied directly to a dimension value.

➢A general tolerance note (normally in the title block).

➢Notes referring to specific parts.

➢Through the use of appropriate symbols (Geometric Tolerancing).

TOLERANCING
Tolerance Representation

Ø 1.50 ± .05   Ø 1.250 ± .005   Ø 1.000 ± .005

R 9.00 ± .05   Ø 1.20 ± .05

R 10.00 ± .05

4.000 ± .005

Tolerances applied directly to a dimension value.

-A-

◎ | ∅ 0.01 | A

Geometric Tolerancing

TOLERANCING
Tolerance Representation

➤Tolerances applied directly to a dimension values maybe in the form of;
  ➤Limit dimensions
  ➤Plus and Minus dimensions (Bilateral or Unilateral)

$\frac{1"}{16}$ *Minimum spacing*

$\frac{3.53}{3.49}$

(A) Direct limits

Limits Dimensions

$22 \begin{smallmatrix} 0 \\ -0.3 \end{smallmatrix}$ 22 ± 0.2

Plus tolerance on top

$12 \begin{smallmatrix} +0.1 \\ 0 \end{smallmatrix}$ $22 \begin{smallmatrix} +0.1 \\ -0.2 \end{smallmatrix}$

$25.6° \begin{smallmatrix} 0 \\ -0.2° \end{smallmatrix}$ $25° \ 15' \pm 0° \ 5'$

(A) Unilateral tolerancing   (B) Bilateral tolerancing

+ & - Dimensions

TOLERANCING

3 HOLES, DIA 6
EQUI-SP

⊕ | 0.12 | A | C

75 ± 0.5

50

○ | 0.2

X – X

// | 0.05 | A   12.5

◎ | 0.08 | B
         C

◎ | 0.1 | B

0.02 | A
B

M30 × 2.5

$60 {}^{+\,0.15}_{-\,0}$

25

3.2

$20 {}^{+0.15}_{-0.00}$

6.3   1.6

3

$20 {}^{+0.12}_{-0.00}$

32

$40 {}^{+0.00}_{-0.12}$

– | 0.02
A

Production Drawing

TOLERANCING
Fits

➤The degree of tightness or looseness between mating parts is called the fit.

➤There are three types;
  ➤Clearance Fits
  ➤Interference Fits
  ➤Transition Fits

4

TOLERANCING
Fits

➢Clearance and Interference Fits

MIN Clearance — ALLOWANCE — MAX Interference
MAX Clearance — Tolerance — MIN Interference
— Tolerance
Tolerance

SHAFT .999 .998

HOLE 1.000 1.001

SHAFT 1.003 1.002

(A)
CLEARANCE FIT
Allowance = + .001

(B)
INTERFERENCE FIT
Allowance = − .003

Allowance always equals smallest hole minus largest shaft

TOLERANCING
Fits

➢Transition Fits

MAX Clearance — ALLOWANCE — MAX Interference
Tolerance

SHAFT .998

HOLE 1.000 1.001

SHAFT 1.002 .998

(A)
CLEARANCE FIT
+ .001

(B)
INTERFERENCE FIT
−.002

TOLERANCING
Fits in Shafts and Holes

➤There are two systems;

  ➤Basic Hole System – minimum hole size is the basic size [preferred in industry since holes are easy to produce to standard sizes from standard drill bits.]

  ➤Basic Shaft System – minimum shaft size is the basic size.

TOLERANCING
Fits in Shafts and Holes

6

TOLERANCING
Fits in Shafts and Holes

ISO Symbol		Description	
Hole Basis	**Shaft Basis**		
Clearance fits	H11/c11	C11/h11	Loose running fit for wide commercial tolerances or allowances on external members
	H9/d9	D9/h9	Free running fit not for use where accuracy is essential, but good for large temperature variations, high running speeds, or heavy journal pressures
	H8/f7	F8/h7	Close running fit for running on accurate machines and for accurate location at moderate speeds and journal pressures
	H7/g6	G7/h6	Sliding fit not intended to run freely but to move and turn freely and locate accurately
Transition fits	H7/h6	H7/h6	Locational clearance fit provides snug fit for locating stationary parts but can be freely assembled and disassembled
	H7/k6	K7/h6	Locational transition fit for accurate location; a compromise between clearance and interference
	H7/n6	N7/h6	Locational transition fit for more accurate location where greater interference is permissible
Interference fits	H7/p6*	P7/h6	Locational interference fit for parts requiring rigidity and alignment with prime accuracy of location but without special bore pressure requirements
	H7/s6	S7/h6	Medium drive fit for ordinary steel parts or shrink fits on light sections; the tightest fit usable with cast iron
	H7/u6	U7/h6	Force fit suitable for parts that can be highly stressed or for shrink fits where the heavy pressing forces required are impractical

More clearance ↑ ... *More interference ↓*

DDEK / 2015 / ME 1

*Transition fit for basic sizes in range from 0 through 3 mm

84

TOLERANCING
Fits in Shafts and Holes

American National Standard Preferred Hole Basis Metric Clearance Fits (ANSI B4.2-1978, R1984)

Basic Size*		Loose Running			Free Running			Close Running			Sliding			Locational Clearance		
		Hole H11	Shaft c11	Fit†	Hole H9	Shaft d9	Fit†	Hole H8	Shaft f7	Fit†	Hole H7	Shaft g6	Fit†	Hole H7	Shaft h6	Fit†
1	Max	1.060	0.940	0.180	1.025	0.980	0.070	1.014	0.994	0.030	1.010	0.998	0.018	1.010	1.000	0.016
	Min	1.000	0.880	0.060	1.000	0.955	0.020	1.000	0.984	0.006	1.000	0.992	0.002	1.000	0.994	0.000
1.2	Max	1.260	1.140	0.180	1.225	1.180	0.070	1.214	1.194	0.030	1.210	1.198	0.018	1.210	1.200	0.016
	Min	1.200	1.080	0.060	1.200	1.155	0.020	1.200	1.184	0.006	1.200	1.192	0.002	1.200	1.194	0.000
1.6	Max	1.660	1.540	0.180	1.625	1.580	0.070	1.614	1.594	0.030	1.610	1.598	0.018	1.610	1.600	0.016
	Min	1.600	1.480	0.060	1.600	1.555	0.020	1.600	1.584	0.006	1.600	1.592	0.002	1.600	1.594	0.000
2	Max	2.060	1.940	0.180	2.025	1.980	0.070	2.014	1.994	0.030	2.010	1.998	0.018	2.010	2.000	0.016
	Min	2.000	1.880	0.060	2.000	1.955	0.020	2.000	1.984	0.006	2.000	1.992	0.002	2.000	1.994	0.000
2.5	Max	2.560	2.440	0.180	2.525	2.480	0.070	2.514	2.494	0.030	2.510	2.498	0.018	2.510	2.500	0.016
	Min	2.500	2.380	0.060	2.500	2.455	0.020	2.500	2.484	0.006	2.500	2.492	0.002	2.500	2.494	0.000
3	Max	3.060	2.940	0.180	3.025	2.980	0.070	3.014	2.994	0.030	3.010	2.998	0.018	3.010	3.000	0.016
	Min	3.000	2.880	0.060	3.000	2.955	0.020	3.000	2.984	0.006	3.000	2.992	0.002	3.000	2.994	0.000
4	Max	4.075	3.930	0.220	4.030	3.970	0.090	4.018	3.990	0.040	4.012	3.996	0.024	4.012	4.000	0.020
	Min	4.000	3.855	0.070	4.000	3.940	0.030	4.000	3.978	0.010	4.000	3.988	0.004	4.000	3.992	0.000
5	Max	5.075	4.930	0.220	5.030	4.970	0.090	5.018	4.990	0.040	5.012	4.996	0.024	5.012	5.000	0.020
	Min	5.000	4.855	0.070	5.000	4.940	0.030	5.000	4.978	0.010	5.000	4.988	0.004	5.000	4.992	0.000
6	Max	6.075	5.930	0.220	6.030	5.970	0.090	6.018	5.990	0.040	6.012	5.996	0.024	6.012	6.000	0.020
	Min	6.000	5.855	0.070	6.000	5.940	0.030	6.000	5.978	0.010	6.000	5.988	0.004	6.000	5.992	0.000
8	Max	8.090	7.920	0.260	8.036	7.960	0.112	8.022	7.987	0.050	8.015	7.995	0.029	8.015	8.000	0.024
	Min	8.000	7.830	0.080	8.000	7.924	0.040	8.000	7.972	0.013	8.000	7.986	0.005	8.000	7.991	0.000
10	Max	10.090	9.920	0.260	10.036	9.960	0.112	10.022	9.987	0.050	10.015	9.995	0.029	10.015	10.000	0.024
	Min	10.000	9.830	0.080	10.000	9.924	0.040	10.000	9.972	0.013	10.000	9.986	0.005	10.000	9.991	0.000
12	Max	12.110	11.905	0.315	12.043	11.956	0.136	12.027	11.984	0.061	12.018	11.994	0.035	12.018	12.000	0.029
	Min	12.000	11.795	0.095	12.000	11.907	0.050	12.000	11.966	0.016	12.000	11.983	0.006	12.000	11.989	0.000
16	Max	16.110	15.905	0.315	16.043	15.950	0.136	16.027	15.984	0.061	16.018	15.994	0.035	16.018	16.000	0.029
	Min	16.000	15.795	0.095	16.000	15.907	0.050	16.000	15.966	0.016	16.000	15.983	0.006	16.000	15.989	0.000
20	Max	20.130	19.890	0.370	20.052	19.935	0.169	20.033	19.980	0.074	20.021	19.993	0.041	20.021	20.000	0.034
	Min	20.000	19.760	0.110	20.000	19.883	0.065	20.000	19.959	0.020	20.000	19.980	0.007	20.000	19.987	0.000

All dimensions are in millimeters.
* The sizes shown are first choice basic sizes (see Table 1). Preferred fits for other sizes can be calculated from data given in ANSI B4.2-1978 (R1984).
† All fits shown in this table have clearance.

DDEK / 2015 / ME 160 – ENGINEERING DRAWING

85

TOLERANCING
Fits in Shafts and Holes

Basic Size*		Loose Running			Free Running			Close Running			Sliding			Locational Clearance		
		Hole H11	Shaft c11	Fit†	Hole H9	Shaft d9	Fit†	Hole H8	Shaft f7	Fit†	Hole H7	Shaft g6	Fit†	Hole H7	Shaft h6	Fit†
25	Max	25.130	24.890	0.370	25.052	24.935	0.169	25.033	24.980	0.074	25.021	24.993	0.041	25.021	25.000	0.034
	Min	25.000	24.760	0.110	25.000	24.883	0.065	25.000	24.959	0.020	25.000	24.980	0.007	25.000	24.987	0.000
30	Max	30.130	29.890	0.370	30.052	29.935	0.169	30.033	29.980	0.074	30.021	29.993	0.041	30.021	30.000	0.034
	Min	30.000	29.760	0.110	30.000	29.883	0.065	30.000	29.959	0.020	30.000	29.980	0.007	30.000	29.987	0.000
40	Max	40.160	39.880	0.440	40.062	39.920	0.204	40.039	39.975	0.089	40.025	39.991	0.050	40.025	40.000	0.041
	Min	40.000	39.720	0.120	40.000	39.858	0.080	40.000	39.950	0.025	40.000	39.975	0.009	40.000	39.984	0.000
50	Max	50.160	49.870	0.450	50.062	49.920	0.204	50.039	49.975	0.089	50.025	49.991	0.050	50.025	50.000	0.041
	Min	50.000	49.710	0.130	50.000	49.858	0.080	50.000	49.950	0.025	50.000	49.975	0.009	50.000	49.984	0.000
60	Max	60.190	59.860	0.520	60.074	59.900	0.248	60.046	59.970	0.106	60.030	59.990	0.059	60.030	60.000	0.049
	Min	60.000	59.670	0.140	60.000	59.826	0.100	60.000	59.940	0.030	60.000	59.971	0.010	60.000	59.981	0.000
80	Max	80.190	79.850	0.530	80.074	79.900	0.248	80.046	79.970	0.106	80.030	79.990	0.059	80.030	80.000	0.049
	Min	80.000	79.660	0.150	80.000	79.826	0.100	80.000	79.940	0.030	80.000	79.971	0.010	80.000	79.981	0.000
100	Max	100.220	99.830	0.610	100.087	99.880	0.294	100.054	99.964	0.125	100.035	99.988	0.069	100.035	100.000	0.057
	Min	100.000	99.610	0.170	100.000	99.793	0.120	100.000	99.929	0.036	100.000	99.966	0.012	100.000	99.978	0.000
120	Max	120.220	119.820	0.620	120.087	119.880	0.294	120.054	119.964	0.125	120.035	119.988	0.069	120.035	120.000	0.057
	Min	120.000	119.600	0.180	120.000	119.793	0.120	120.000	119.929	0.036	120.000	119.966	0.012	120.000	119.978	0.000
160	Max	160.250	159.790	0.710	160.100	159.855	0.345	160.063	159.957	0.146	160.040	159.986	0.079	160.040	160.000	0.065
	Min	160.000	159.540	0.210	160.000	159.755	0.145	160.000	159.917	0.043	160.000	159.961	0.014	160.000	159.975	0.000
200	Max	200.290	199.760	0.820	200.115	199.830	0.400	200.072	199.950	0.168	200.046	199.985	0.090	200.046	200.000	0.075
	Min	200.000	199.470	0.240	200.000	199.715	0.170	200.000	199.904	0.050	200.000	199.956	0.015	200.000	199.971	0.000
250	Max	250.290	249.720	0.860	250.115	249.830	0.400	250.072	249.950	0.168	250.046	249.985	0.090	250.046	250.000	0.075
	Min	250.000	249.430	0.280	250.000	249.715	0.170	250.000	249.904	0.050	250.000	249.956	0.015	250.000	249.971	0.000
300	Max	300.320	299.670	0.970	300.130	299.810	0.450	300.081	299.944	0.189	300.052	299.983	0.101	300.052	300.000	0.084
	Min	300.000	299.350	0.330	300.000	299.680	0.190	300.000	299.892	0.056	300.000	299.951	0.017	300.000	299.968	0.000
400	Max	400.360	399.600	1.120	400.140	399.790	0.490	400.089	399.938	0.208	400.057	399.982	0.111	400.057	400.000	0.093
	Min	400.000	399.240	0.400	400.000	399.650	0.210	400.000	399.881	0.062	400.000	399.946	0.018	400.000	399.964	0.000
500	Max	500.400	499.520	1.280	500.155	499.770	0.540	500.097	499.932	0.228	500.063	499.980	0.123	500.063	500.000	0.103
	Min	500.000	499.120	0.480	500.000	499.615	0.230	500.000	499.869	0.068	500.000	499.940	0.020	500.000	499.960	0.000

All dimensions are in millimeters.
* The sizes shown are first choice basic sizes (see Table 1). Preferred fits for other sizes can be calculated from data given in ANSI B4.2-1978 (R1984).
† All fits shown in this table have clearance.

TOLERANCING
Fits in Shafts and Holes
BRITISH STANDARD
SELECTED ISO FITS—HOLE BASIS

Extracted from BS 4500 : 1969

Data Sheet 4500A
Issue 1, February 1970
confirmed August 1985

Nominal sizes		Tolerance		Tolerance		Tolerance		Tolerance		Tolerance		Tolerance		Tolerance		Tolerance		Tolerance		Tolerance		Nominal sizes	
Over	To	H11	c11	H9	d10	H9	e9	H8	f7	H7	g6	H7	h6	H7	k6	H7	n6	H7	p6	H7	s6	Over	To
mm	mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	0.001 mm	mm	mm
—	3	+60 / 0	−60 / −120	+25 / 0	−20 / −60	+25 / 0	−14 / −39	+14 / 0	−6 / −16	+10 / 0	−2 / −8	+10 / 0	−6 / 0	+10 / 0	+6 / 0	+10 / 0	+10 / +4	+10 / 0	+12 / +6	+10 / 0	+20 / +14	—	3
3	6	+75 / 0	−70 / −145	+30 / 0	−30 / −78	+30 / 0	−20 / −50	+18 / 0	−10 / −28	+12 / 0	−4 / −12	+12 / 0	−8 / 0	+12 / 0	+9 / +1	+12 / 0	+16 / +8	+12 / 0	+20 / +12	+12 / 0	+27 / +19	3	6
6	10	+90 / 0	−80 / −170	+36 / 0	−40 / −98	+36 / 0	−25 / −61	+22 / 0	−13 / −35	+15 / 0	−5 / −14	+15 / 0	−9 / 0	+15 / 0	+10 / +1	+15 / 0	+19 / +10	+15 / 0	+24 / +15	+15 / 0	+32 / +23	6	10
10	18	+110 / 0	−95 / −205	+43 / 0	−50 / −120	+43 / 0	−32 / −75	+27 / 0	−16 / −34	+18 / 0	−6 / −17	+18 / 0	−11 / 0	+18 / 0	+12 / +1	+18 / 0	+23 / +12	+18 / 0	+29 / +18	+18 / 0	+39 / +28	10	18
18	30	+130 / 0	−110 / −240	+52 / 0	−65 / −149	+52 / 0	−40 / −92	+33 / 0	−20 / −41	+21 / 0	−7 / −20	+21 / 0	−13 / 0	+21 / 0	+15 / +2	+21 / 0	+28 / +15	+21 / 0	+35 / +22	+21 / 0	+48 / +35	18	30
30	40	+160 / 0	−120 / −280	+62 / 0	−80 / −180	+62 / 0	−50 / −112	+39 / 0	−25 / −50	+25 / 0	−9 / −25	+25 / 0	−16 / 0	+25 / 0	+18 / +2	+25 / 0	+33 / +17	+25 / 0	+42 / +26	+25 / 0	+59 / +43	30	40
40	50	+160 / 0	−130 / −290																			40	50
50	65	+190 / 0	−140 / −330	+74 / 0	−100 / −220	+74 / 0	−60 / −134	+46 / 0	−30 / −60	+30 / 0	−10 / −29	+30 / 0	−19 / 0	+30 / 0	+21 / +2	+30 / 0	+39 / +20	+30 / 0	+51 / +32	+30 / 0	+72 / +53	50	65
65	80	+190 / 0	−150 / −340																	+30 / 0	+78 / +59	65	80
80	100	+220 / 0	−170 / −390	+87 / 0	−120 / −260	+87 / −0	−72 / −159	+54 / 0	−36 / −71	+35 / 0	−12 / −34	+35 / 0	−22 / 0	+35 / 0	+25 / +3	+35 / 0	+45 / +23	+35 / 0	+59 / +37	+35 / 0	+93 / +71	80	100
100	120	+220 / 0	−180 / −400																	+35 / 0	+101 / +79	100	120
120	140	+250 / 0	−200 / −450	+100 / 0	145 / 305	+100 / 0	−84 / −185	+63 / 0	−43 / −83	+40 / 0	−14 / −39	+40 / 0	−25 / 0	+40 / 0	+28 / +3	+40 / 0	+52 / +27	+40 / 0	+68 / +43	+40 / 0	+117 / +92	120	140
140	160	+250 / 0	−210 / −460																	+40 / 0	+125 / +100	140	160
160	180	+250 / 0	−230 / −480																	+40 / 0	+133 / +108	160	180
180	200	+290 / 0	−240 / −530	+115 / 0	−170 / −355	+115 / 0	−100 / −215	+72 / 0	−50 / −96	+46 / 0	−15 / −44	+46 / 0	−29 / 0	+46 / 0	+33 / +4	+46 / 0	+60 / +31	+46 / 0	+79 / +50	+46 / 0	+151 / +122	180	200
200	225	+290 / 0	−260 / −550																	+46 / 0	+159 / +130	200	225
225	250	+290 / 0	−280 / −570																	+46 / 0	+169 / +140	225	250
250	280	+320 / 0	−300 / −620	+130 / 0	−190 / −400	+130 / 0	−110 / −240	+81 / 0	−56 / −108	+52 / 0	−17 / −49	+52 / 0	−32 / 0	+52 / 0	+36 / +4	+52 / 0	+66 / +34	+52 / 0	+88 / +56	+52 / 0	+190 / +158	250	280
280	315	+320 / 0	−330 / −650																	+52 / 0	+202 / +170	280	315
315	355	+360 / 0	−360 / −720	+140 / 0	−210 / −440	+140 / 0	−125 / −265	+89 / 0	−62 / −119	+57 / 0	−18 / −54	+57 / 0	−36 / 0	+57 / 0	+40 / +4	+57 / 0	+73 / +37	+57 / 0	+98 / +62	+57 / 0	+226 / +190	315	355
355	400	+360 / 0	−400 / −760																	+57 / 0	+244 / +208	355	400
400	450	+400 / 0	−440 / −840	+155 / 0	−230 / −480	+155 / 0	−135 / −290	+97 / 0	−68 / −131	+63 / 0	−20 / −60	+63 / 0	−40 / 0	+63 / 0	+45 / +5	+63 / 0	+80 / +40	+63 / 0	+108 / +68	+63 / 0	+272 / +232	400	450
450	500	+400 / 0	−480 / −880																	+63 / 0	+292 / +252	450	500

TOLERANCING
Represeting Fit type on drawings

$\varnothing \begin{smallmatrix} 39.991 \\ 39.975 \end{smallmatrix}$

$\varnothing \begin{smallmatrix} 40.025 \\ 40.000 \end{smallmatrix}$

Method 1
Limit Form

Ø 40g6

Ø 40H7

Method 2
Note Form

88

9