GENERAL INFORMATION

1.1 Purpose of This Document

The purpose of this document is to describe the dimensional and geometrical tolerances applied by TMA in the manufacturing of metal work pieces for which no customer specifications have been provided.

1.2 References

NF EN 22768-1: Tolerances for linear and angular dimensions without individual tolerance indications

NF E 02-352: Cut and bent work pieces – Dimensional and geometrical tolerances for dimensions and items without individual tolerance indications

ISO 9013: Thermal cutting – Classification of thermal cuts – Geometrical product specification and quality tolerances

NF E 86-051: Industrial installations – General tolerances for items obtained by oxygen cutting

DIN 6930 Teil 2: Steel stampings – General tolerances

NF EN ISO 13920: Welding – General tolerances for welded constructions

NF EN ISO 8503: Surface roughness characteristics of blast-cleaned steel substrates

NF EN ISO 8501-1: Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness, summarized in OHGPI document on Technical specifications for abrasive blasting

IMPORTANT:

- **Unless otherwise stated, all dimensions cited in this document are in millimeters (mm).**
- **In tolerance tables with multiple tolerance classes, the standard TMA class is highlighted in blue.**

2 Standard Tolerances for Oxyfuel Cutting

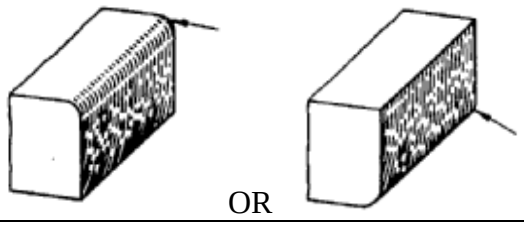
2.1 Dimensional Tolerances

As per NF E 86-051

Thickness of sheet (th)	Range of dimensions	Limit Deviations
0< th <= 15	L<= 315	+/-1
	315 < L<= 600	+/-2
	600 < L <= 1500	+/-2
	L > 1500	+/-2.5
15< th <= 40	L<= 315	+/-1.5
	315 < L<= 600	+/-2
	600 < L <= 1500	+/-2.5
	L > 1500	+/-2.5
40< th <= 70	L<= 315	+/-2
	315 < L<= 600	+/-2.5
	600 < L <= 1500	+/-3
	L > 1500	+/-3
70< th <= 100	L<= 315	+/-2.5
	315 < L<= 600	+/-3
	600 < L <= 1500	+/-3
	L > 1500	+/-3.5
th > 100	L<= 315	+/-3
	315 < L<= 600	+/-3
	600 < L <= 1500	+/-3.5
	L > 1500	+/-4

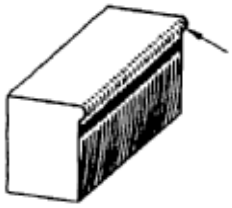
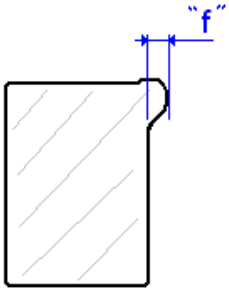
2.2 Cut Edge Defects

2.2.1 Molten Edge

 OR	Minor defect not taken into account

2.2.2 Cut Edge Overhang “f”

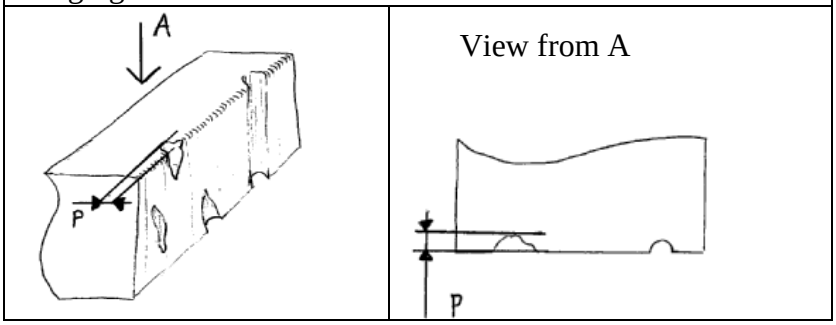
Definition: excess material on upper edge

		**Thickness**	**MAX dimension**
		≤ 20 mm 21 to 40 mm 41 to 60 mm > 60 mm	1 mm 1.2 mm 1.4 mm 1.6 mm

2.3 Gouging Depth “p”

Definition: scourings or kerves of limited depth on the cut surface, generally in the direction of cut thickness

Gouging defect

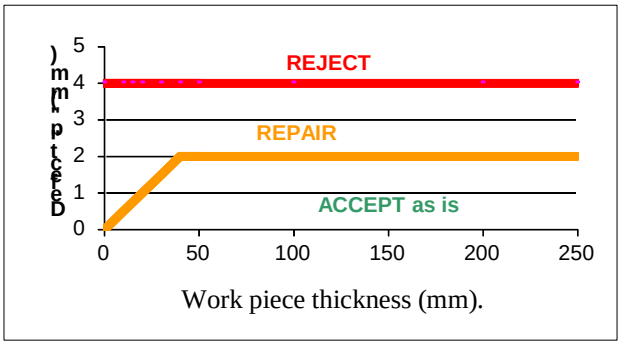


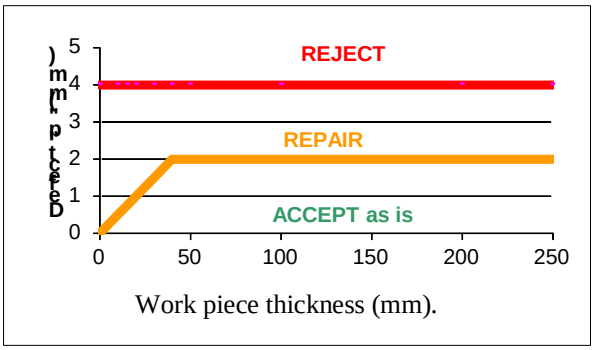
Accept: “p” no greater than 5% of thickness and less than 2 mm deep

Repair: defect less than 4 mm

Defects are filled in by welding followed by grinding.

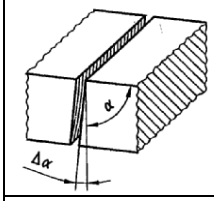
Reject: “p” greater than 4 mm





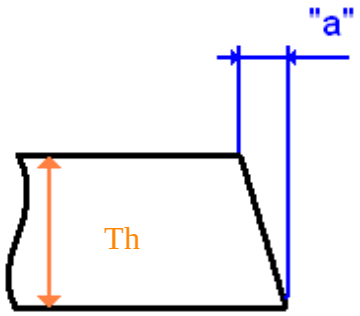
2.4 Perpendicularity (Squareness of Cut)

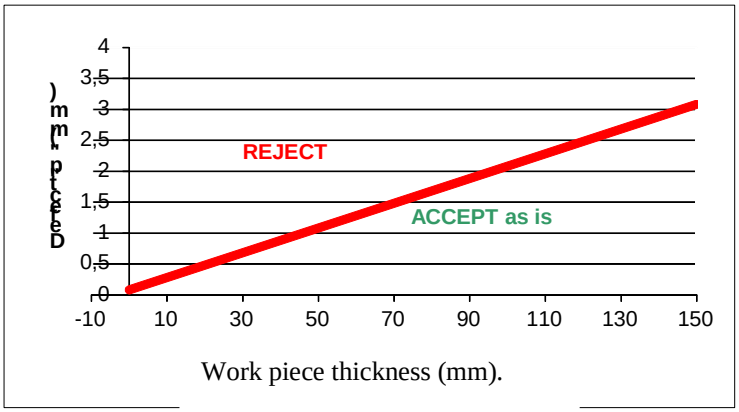
Tolerances according to ISO 9013 Tolerance class 4



Maximum deviation:

max a = 0.08 + 0.02 * th





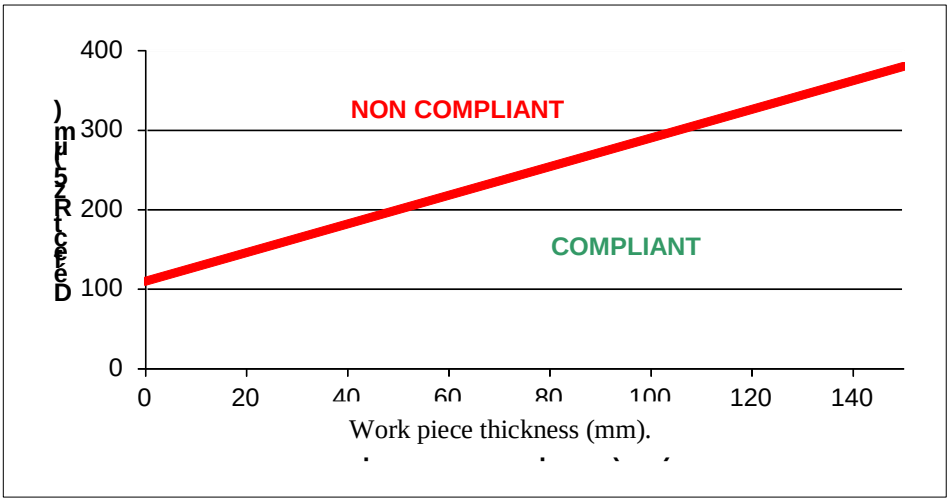
2.5 Flatness

Corresponds to standards of flatness for the metal from which the work pieces are cut.

2.6 Roughness

Tolerances according to ISO 9013 Tolerance class 4

Mean height of the profile (µm): Rz5 = 110 + (1.8 * th: mm)



3 Standard Tolerances for Laser Cutting

3.1 Dimensional Tolerances

As per NF EN 22768-1 Class m

Table 1:

Tolerance class		Permissible deviations for linear dimensions except for broken edges (external radii and chamfer heights, see Table 2)							
Designation	Description	0.5 to 3	over de 3 up to 6	over 6 up to 30	over 30 up to 120	over 120 up to 400	over 400 up to 1000	over 1000 up to 2000	over 2000 up to 4000
f	fine	±0.05	±0.05	±0.1	±0.15	±0.2	±0.3	±0.5	-
m	**medium**	**±0.1**	**±0.1**	**±0.2**	**±0.3**	**±0.5**	**±0.8**	**±1.2**	**±2**
c	coarse	±0.2	±0.3	±0.5	±0.8	±1.2	±2	±3	±4
v	very coarse	-	±0.5	±1	±1.5	±2.5	±4	±6	±8

Table 2:

Tolerance class		**External radii and chamfer heights**		
Designation	Description	0.5 to 3	over 3 up to 6	over 6 up to 30
f	fine	**±0.2**	**±0.5**	**±1**
m	**medium**			
c	coarse	±0.4	±1	±2
v	very coarse			

3.2 Flatness

Corresponds to standards of flatness for the metal from which the work pieces are cut.

3.3 Coaxiality/Symmetry

Range of nominal sizes	Tolerance class	Coaxiality and symmetry tolerances per thickness range				
		0.1 to 0.35	over 0.35 up to 1	over 1 up to 3	over 3 up to 6	over 6 up to 10
1 to 6	narrow (e)	0.1	0.12	0.15	0.2	-
	normal (n)	0.2	0.24	0.3	0.4	-
	wide (l)	0.3	0.4	0.6	0.8	-
over 6 up to 10	e	0.1	0.15	0.2	0.3	0.4
	n	0.2	0.3	0.4	0.5	0.7
	l	0.4	0.6	0.8	1.0	1.4
over 10 up to 25	e	0.15	0.2	0.25	0.3	0.4
	n	0.3	0.4	0.5	0.6	0.8
	l	0.6	0.8	1.0	1.2	1.6
over 25 up to 63	e	0.2	0.25	0.3	0.4	0.5
	n	0.4	0.5	0.6	0.8	1.0
	l	0.8	1.0	1.2	1.6	2.0
over 63 up to 160	e	0.25	0.3	0.4	0.5	0.6
	n	0.5	0.6	0.8	1.0	1.2
	l	1.0	1.2	1.6	2.0	2.4
over 160 up to 400	e	0.4	0.4	0.5	0.6	0.8
	n	0.8	0.8	1.0	1.2	1.6
	l	1.6	1.6	2.0	2.4	3.2
over 400 up to 1000	e	0.7	0.7	0.7	1.0	1.0
	n	1.6	1.6	1.6	2.0	2.0
	l	3.2	3.2	3.2	4.0	4.0
over 1000 up to 3000	e	-	1.6	1.6	2.0	2.0
	n	-	3.0	3.0	3.5	4.0
	l	-	6.0	6.0	8.0	8.0

4 Standard Tolerances for Stamping

As per DIN 6930 Class m

4.1 General Tolerances on Length

Nominal size range	Accuracy grade	Thickness				
		≥ 0.1 and ≤ 1	> 1 and ≤ 3	> 3 and ≤ 6	> 6 and ≤ 10	>10
≥ 1 and ≤ 6	fine (f)	± 0.05	± 0.08	± 0.1	± 0.2	± 0.4
	medium (m)	± 0.1	± 0.15	± 0.2	± 0.3	± 0.4
	coarse (g)	± 0.2	± 0.3	± 0.4	± 0.6	± 0.8
	very coarse (sg)	± 0.5	± 0.5	± 0.8	± 1.2	± 1.5
> 6 and ≤ 10	f	± 0.08	± 0.1	± 0.15	± 0.2	± 0.4
	m	± 0.15	± 0.2	± 0.25	± 0.4	± 0.4
	g	± 0.3	± 0.4	± 0.5	± 0.8	± 0.8
	sg	± 0.8	± 1	± 1	± 1.5	± 1.5
> 10 and ≤ 25	f	± 0.1	± 0.1	± 0.15	± 0.2	± 0.4
	m	± 0.2	± 0.25	± 0.3	± 0.4	± 0.6
	g	± 0.4	± 0.5	± 0.6	± 0.8	± 1
	sg	± 1	± 1	± 1.5	± 1.5	± 2
> 25 and ≤ 63	f	± 0.1	± 0.15	± 0.2	± 0.3	± 0.4
	m	± 0.25	± 0.3	± 0.4	± 0.5	± 0.6
	g	± 0.5	± 0.6	± 0.8	± 1	± 1.2
	sg	± 1	± 1	± 1.5	± 2	± 3
> 63 and ≤ 160	f	± 0.15	± 0.15	± 0.2	± 0.3	± 0.4
	m	± 0.3	± 0.4	± 0.5	± 0.6	± 0.8
	g	± 0.6	± 0.8	± 1	± 1.2	± 1.6
	sg	± 1.5	± 1.5	± 2	± 3	± 3
> 160 and ≤ 400	f	± 0.2	± 0.3	± 0.3	± 0.4	± 0.5
	m	± 0.5	± 0.6	± 0.6	± 0.8	± 1
	g	± 1	± 1.2	± 1.2	± 1.6	± 2
	sg	± 1.5	± 2	± 2.5	± 3	± 3
> 400 and ≤ 1000	f	± 0.4	± 0.4	± 0.5	± 0.5	± 0.8
	m	± 0.8	± 0.8	± 1	± 1	± 1.5
	g	± 1.6	± 1.6	± 2	± 2	± 3
	sg	± 2.5	± 2.5	± 3	± 4	± 4
> 1000 and ≤ 6300	f	± 0.8	± 0.8	± 0.8	± 1	± 1
	m	± 1.2	± 1.5	± 1.5	± 2	± 2
	g	± 2.5	± 2.5	± 3	± 4	± 4
	sg	± 4	± 4	± 4	± 4	± 4

4.2 Flatness

Corresponds to standards of flatness for the metal from which the work pieces are cut.

4.3 Tolerances on Radius

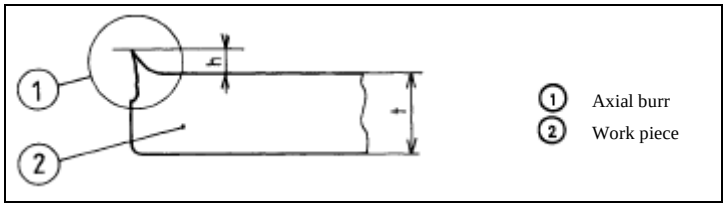
Nominal size range	Accuracy grade	Thickness				
		≥ 0.1 and ≤ 1	> 1 and ≤ 3	> 3 and ≤ 6	> 6 and ≤ 10	>10
≥ 1 and ≤ 6	f, m	± 0.2	± 0.3	± 0.5	-	-
	g, sg	± 0.4	± 0.6	± 1	-	-
> 6 and ≤ 10	f, m	± 0.3	± 0.4	± 0.5	± 0.6	-
	g, sg	± 0.6	± 0.8	± 1	± 1.2	-
> 10 and ≤ 25	f, m	± 0.4	± 0.5	± 0.6	± 0.8	± 1
	g, sg	± 0.8	± 1	± 1.2	± 1.6	± 2
> 25 and ≤ 63	f, m	± 0.5	± 0.6	± 0.8	± 1	± 1.2
	g, sg	± 1	± 1.2	± 1.6	± 2	± 2.4
> 63 and ≤ 160	f, m	± 0.8	± 1	± 1.2	± 1.4	± 1.6
	g, sg	± 1.6	± 2	± 2.4	± 2.8	± 3.2
> 160 and ≤ 400	f, m	± 1	± 1.2	± 1.5	± 1.8	± 2
	g, sg	± 2	± 2.4	± 3	± 3.6	± 4
> 400	f, m	± 1.6	± 2	± 2.2	± 2.5	± 3
	g, sg	± 3.2	± 4	± 4.4	± 5	± 6

4.4 Angular Tolerances

Quality	Length of the shorter leg							
	≥ 1 and ≤ 6	> 6 and ≤ 10	> 10 and ≤ 25	> 25 and ≤ 63	> 63 and ≤ 160	> 160 and ≤ 400	> 400 and ≤ 1000	> 1000 and ≤ 2500
f	± 1°	± 1°	± 30’	± 30’	± 20’	± 10’	± 5’	± 5’
m	± 1° 30’	± 1° 30’	± 50’	± 50’	± 25’	± 15’	± 10’	± 10’
g, sg	± 3°	± 3°	± 2°	± 2°	± 1°	± 30’	± 20’	± 20’

4.5 Burrs

This section is specifically about axial burrs, i.e. burrs that develop based on the direction of movement of the cutting tool.



Axial Burr

Axial burrs must be no more than **1/10th the thickness** of the stamping: **h ≤ 0.1 * th**

5 Standard Tolerances for Bending

As per NF E 02-352 “Normal” class:

IMPORTANT: This standard does not account for thicknesses of greater than 10 mm. Tolerances for work pieces thicker than 10 mm are thus, by default, the same as those for 10 mm pieces.

5.1 Angular Deviations

Tolerance class	**Admissible deviations for all size ranges**
Narrow (e)	± 1°
Normal (n)	± 1.5°
Wide (l)	± 2°

5.2 Height of a Bent Edge

Range of nominal sizes	Tolerance class	Maximum admissible deviations in height per thickness range				
		0.1 to 0.35	**over 0.35 to 1**	**over 1 to 3**	**over 3 to 6**	**over 6 to10**
1 to 6	**e**	± 0.15	± 0.15	± 0.20	-	-
	n	± 0.30	± 0.30	± 0.40	-	-
	l	± 0.60	± 0.60	± 0.80	-	-
over 6 up to 10	**e**	± 0.15	± 0.15	± 0.20	± 0.30	-
	n	± 0.30	± 0.30	± 0.40	± 0.60	-
	l	± 0.60	± 0.60	± 0.80	± 1.20	-
over 10 up to 25	**e**	± 0.20	± 0.20	± 0.25	± 0.30	± 0.40
	n	± 0.40	± 0.40	± 0.50	± 0.60	± 0.80
	l	± 0.80	± 0.80	± 1.00	± 1.20	± 1.60
over 25 up to 63	**e**	± 0.25	± 0.25	± 0.30	± 0.35	± 0.40
	n	± 0.50	± 0.50	± 0.60	± 0.70	± 0.80
	l	± 1.00	± 1.00	± 1.20	± 1.40	± 1.60
over 63 up to 160	**e**	± 0.30	± 0.30	± 0.35	± 0.35	± 0.50
	n	± 0.60	± 0.60	± 0.70	± 0.70	± 1.00
	l	± 1.20	± 1.20	± 1.40	± 1.40	± 2.00
over 160 up to 500	**e**	± 0.35	± 0.35	± 0.40	± 0.40	± 0.50
	n	± 0.70	± 0.70	± 0.80	± 0.80	± 1.00
	l	± 1.40	± 1.40	± 1.60	± 1.60	± 2.00

5.3 Admissible Deviations in Outer Distance between Two Bent Edges

Range of nominal sizes	Tolerance class	Admissible deviations per thickness range				
		0.1 to 0.35	**over 0.35 to 1**	**over 1 to 3**	**over 3 to 6**	**over 6 to10**
1 to 6	**e**	± 0.20	± 0.20	± 0.25	-	-
	n	± 0.40	± 0.40	± 0.50	-	-
	l	± 0.80	± 0.80	± 1.00	-	-
over 6 up to 10	**e**	± 0.20	± 0.20	± 0.25	-	-
	n	± 0.40	± 0.40	± 0.50	-	-
	l	± 0.80	± 0.80	± 1.00	-	-
over 10 up to 25	**e**	± 0.25	± 0.25	± 0.25	± 0.35	-
	n	± 0.50	± 0.50	± 0.50	± 0.70	-
	l	± 1.00	± 1.00	± 1.00	± 1.40	-
over 26 up to 63	**e**	± 0.30	± 0.30	± 0.30	± 0.40	± 0.45
	n	± 0.60	± 0.60	± 0.60	± 0.80	± 0.90
	l	± 1.20	± 1.20	± 1.20	± 1.60	± 1.80
over 63 up to 160	**e**	± 0.35	± 0.35	± 0.40	± 0.45	± 0.60
	n	± 0.70	± 0.70	± 0.80	± 0.90	± 1.20
	l	± 1.40	± 1.40	± 1.60	± 1.80	± 2.50
over 160 up to 400	**e**	± 0.40	± 0.40	± 0.45	± 0.50	± 0.70
	n	± 0.80	± 0.80	± 0.90	± 1.00	± 1.40
	l	± 1.60	± 1.60	± 1.80	± 2.00	± 2.80
over 400 up to 1000	**e**	± 0.50	± 0.50	± 0.60	± 0.75	± 0.90
	n	± 1.00	± 1.00	± 1.00	± 1.50	± 1.80
	l	± 2.00	± 2.00	± 2.00	± 3.00	± 3.50
over 1000 up to 3000	**e**	-	± 0.80	± 1.00	± 1.50	± 2.00
	n	-	± 1.70	± 2.00	± 3.00	± 4.00
	l	-	± 3.50	± 4.00	± 5.00	± 6.00

6 Standard Tolerances for Welding

6.1 Tolerances on Linear Dimensions

As per EN ISO 13920 Class B:

Tolerance class	Nominal sizes										
	2 to 30	>30 up to 120	>120 up to 400	>400 up to 1000	>1000 up to 2000	>2000 up to 4000	>4000 up to 8000	>8000 up to 12000	>12000 up to 16000	>16000 up to 20000	>20000
	Tolerances										
A	± 1	± 1	± 1	± 2	± 3	± 4	± 5	± 6	± 7	± 8	± 9
B		± 2	± 2	± 3	± 4	± 6	± 8	± 10	± 12	± 14	± 16
C		± 3	± 4	± 6	± 8	± 11	± 14	± 18	± 21	± 24	± 27
D		± 4	± 7	± 9	± 12	± 16	± 21	± 27	± 32	± 36	± 40

6.2 Tolerances on Angular Dimensions

As per EN ISO 13920 Class B:

Tolerance class	Nominal sizes		
	up to 400	> 400 up to 1000	> 1000
	Tolerances		
A	± 20’	± 15’	± 10’
B	± 45’	± 30’	± 20’
C	± 1°	± 45’	± 30’
D	± 1° 30’	± 1° 15’	± 1°
	Calculated and rounded tolerances (in mm/m) [1]		
A	± 6	± 4.5	± 3
B	± 13	± 9	± 6
C	± 18	± 13	± 9
D	± 26	± 22	± 18
1) The value indicated in mm/m must be multiplied by the length in meters of the shorter leg.			

6.3 Straightness, Flatness, and Parallelism Tolerances

As per EN ISO 13920 Class F:

Tolerance class	**Nominal sizes**									
	> 30 up to 120	> 120 up to 400	> 400 up to 1000	> 1000 up to 2000	> 2000 up to 4000	> 4000 up to 8000	> 8000 up to 12000	> 12000 up to 16000	> 16000 up to 20000	> 20000
	Tolerances									
E	0.5	1	1.5	2	3	4	5	6	7	8
F	1	1.5	3	4.5	6	8	10	12	14	16
G	1.5	3	5.5	9	11	16	20	22	25	25
H	2.5	5	9	14	18	26	32	36	40	40

7 Shot-blasting

The quality of shot-blasting is as follows:

- Cleanliness or degree of preparation **Sa 2 ½** (ISO 8501-1)
- **Medium** roughness (NF EN ISO 8503)

8 Indications for Measurement

8.1 Oxyfuel and Laser Cut Pieces

Measurements should be taken on oxide-free cut surfaces away from imperfections. Cut edges should be clean and even.

8.2 Stampings

Stampings are, by definition, subjected to deformation during the manufacturing process (see diagram below). Measurements should be taken from non-deformed zones.

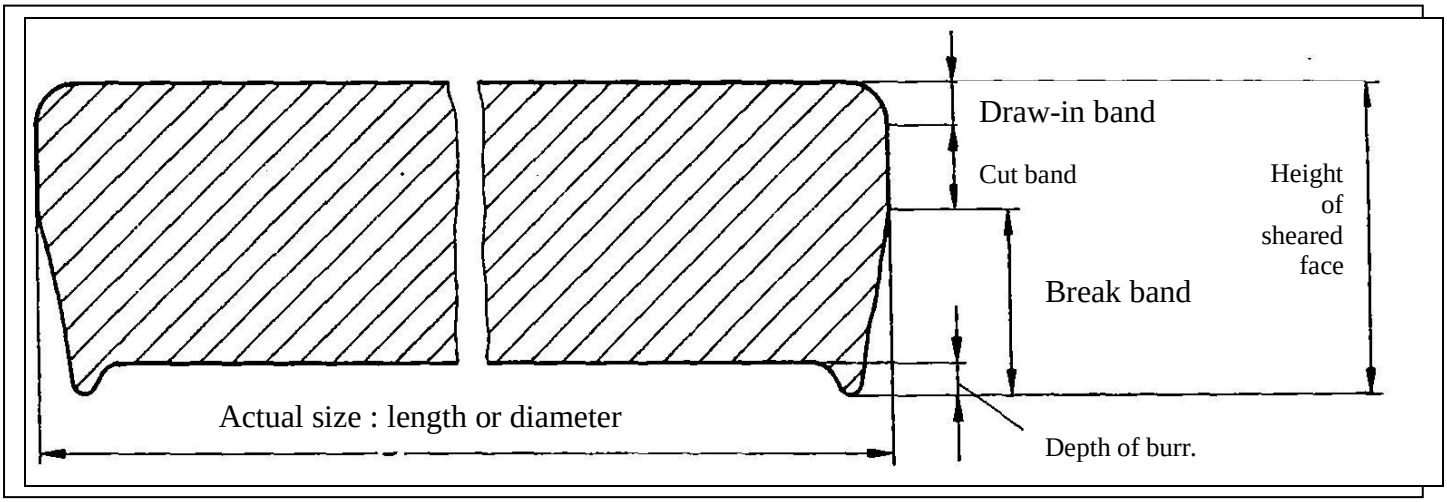


Diagram of a stamping

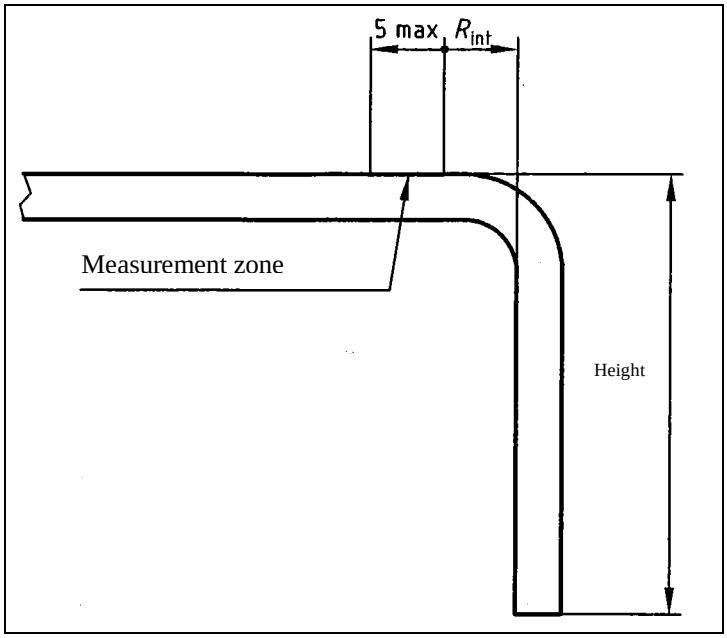
Break band

8.3 Angle Measurements

8.3.1 Height of a Bent Edge

The zone measured should be no farther than 5 mm from the zone affected by the bending deformation (see diagram below).
In other words, measurements should be taken as close as possible to the bend, but not in it (which would invalidate the re

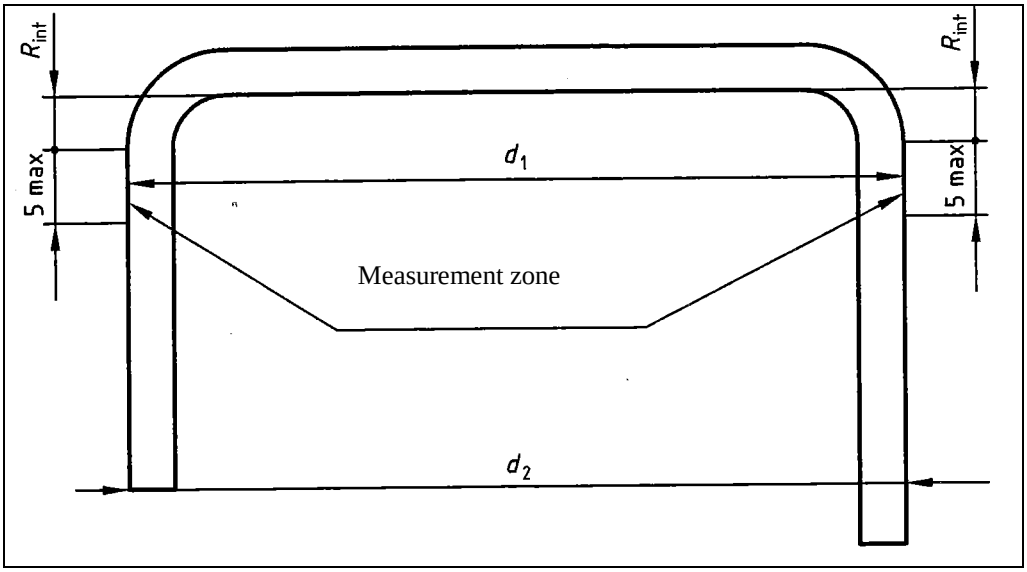
Actual size : length or diameter



Measurement zone for the height of a bent edge

8.3.2 Distance between Two Bent Edges

Apply the same rules as for the measurement of the height of a bent edge. Measurements should be taken at the base of the bend and away from the deformed zone (see diagram below).

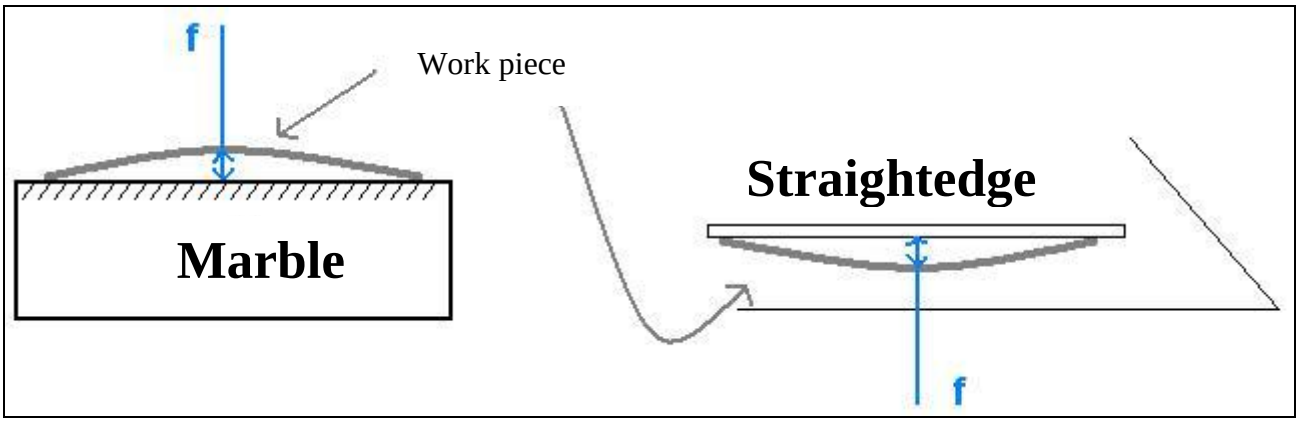


Measurement zone for the outer distance between two bent edges

8.4 Flatness

The work piece should be positioned against the straightedge for minimal deflection (best-case scenario).

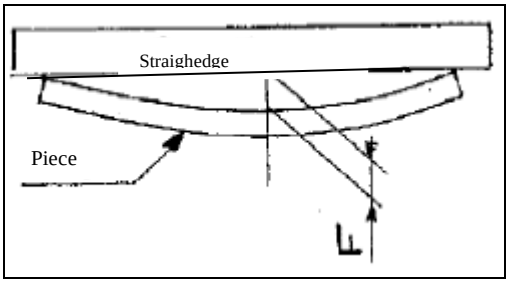
Deflection should be measured between the concave (inner) surface of the work piece and the straightedge (or marble).



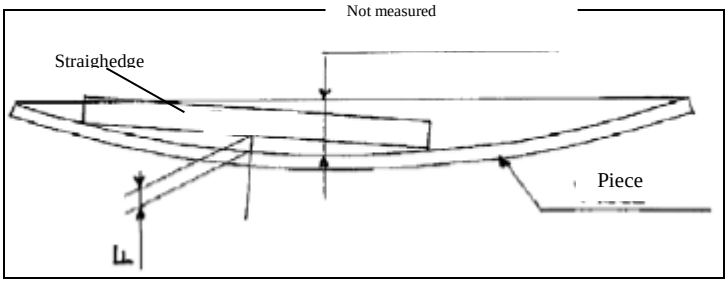
Measurement of flatness defects: maximum deflection “f”

If the straightedge is longer than the work piece, flatness should be measured for the entire work piece.

If the straightedge is shorter than the work piece, measurements should be relative to the length of the work piece covered by the straightedge.



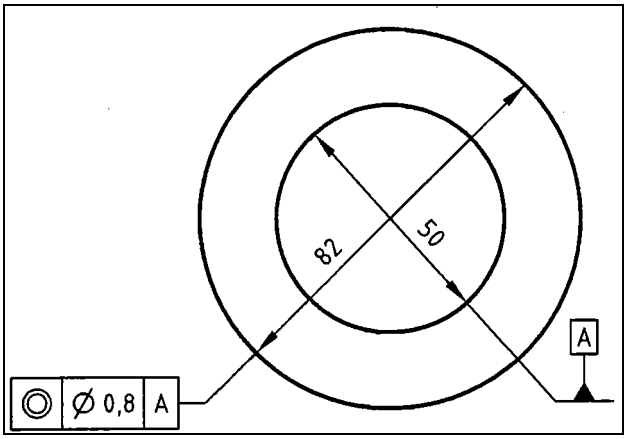
Straightedge longer than work piece



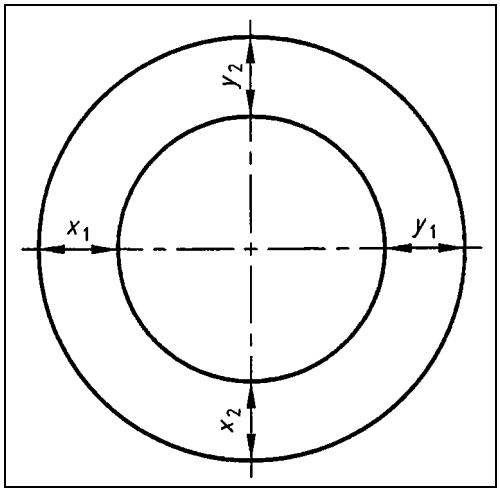
Work piece longer than straightedge

8.5 Coaxiality

One approximate method involves measuring the differences between opposing radii on two orthogonal planes. The difference between x_i and y_i should be no greater than the coaxiality tolerance (0.8 in the example below).



Example specifications



Approximate approach for verifying coaxiality tolerance

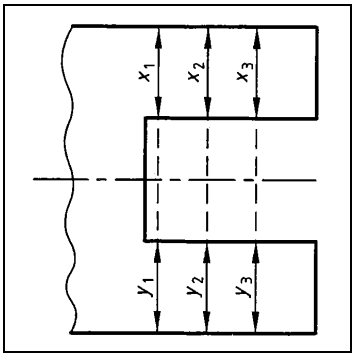
In the example above, measurements are as follows:

$x_1 = 31$, $y_1 = 31.6$, $x_2 = 31.3$, $y_2 = 31.4$

Therefore: $|x_1 - y_1| = 0.6 \leq 0.8$ and $|x_2 - y_2| = 0.1 \leq 0.8$ → Coaxiality is compliant.

8.6 Symmetry

One approximate method involves measuring differences in width orthogonally to the axial plane. The difference between x_i and y_i should be no greater than the tolerance "t".



Approximate method for verifying symmetrical tolerance

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