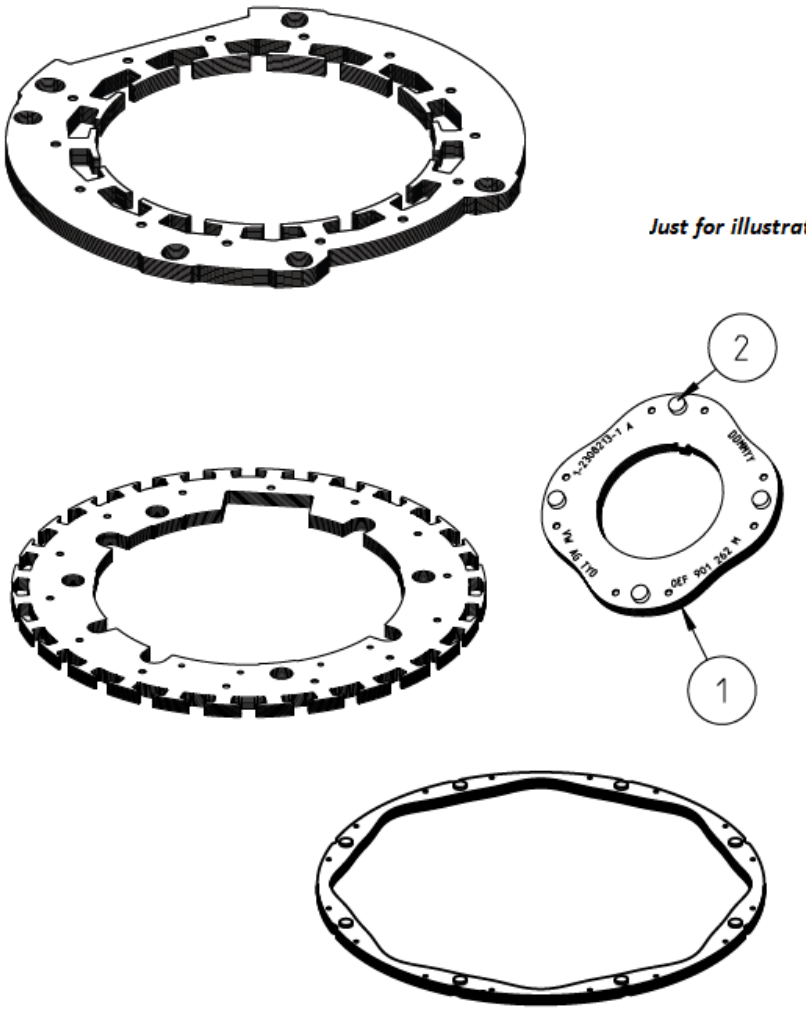
Measuring guide for Resolver (rotor/stator package)



Just for illustration

F	Adaptations to reflect current standards	24 MAR 2023
E2	Update for measuring outside diameter of the rotor	23 JUL 2013
E1	Status correction: setting E-version from “Preliminary” to “active” status in DMTec	22 APR 2013
E	Full review	22 APR 2013
D	Calculation Cm and Cmk on basis of average 3 measuring points Use probe 4.0 mm instead of 1.35 mm Corrected typo error Adjust measuring points to a wider position for outside diameter -1.5°; 0°; +1.5° Adjust measuring points to a wider position for stator pole -3.5°; 0°; +3.5° Add requirements xy coordinates to be delivered in measuring report	16 SEP 2010
Rev	**Description of change**	**Date**

B. Cailleeuw	DATE xx/xx/20xx	Steven Van Nimmen	ECR-xx-xxxxxx	DATE 24-03-2023

0. CONTENTS

1. USAGE OF THE SPECIFICATION

This spec must be used for all measurements of the resolver rotor and stator parts e.g.:
- Measuring comparison on 5 parts FOT-parts and 5 PPAP parts
- Measurement reports including PPAP releases
- MSA study type 1&3 according to TE-spec QMP_EMEA_027
- Capability studies according to TE-spec QMP_EMEA_050
- Production controls

Remark that the datums defined on rotor and stator must be used for all parts in the following process steps.
Datum A is preferably defined on the lamella with the thru holes (starting / separating lamella)
The overview of the standard defined datum names of the measurement system:
- Datum A = measurement plane
- Datum B = center point
- Datum C = starting position (0°)
- Datum D = measurement level (low) relative to datum A
- Datum E = measurement level (middle) relative to datum A
- Datum F = measurement level (upper) relative to datum A
- Datum G = orientation defined relative to datum C, e.g. for measurement of contacts

Conclusion: on all drawings the same measurement system must be defined with this mandatory note:
Measuring according to TE-spec 109-90816

2. DOCUMENTATION

For reporting the TE EMEA dimensional report (PE-AUT-AV-00011-001) is used.
It must contain:
- Confirmation that this measurement specification is used
- The measurement setup (measurement equipment, fixture, probe, …) explained with pictures
- All measurements according to drawing using the Dim-Nrs
- All individual values (x,y-coordinates of the measuring data) reported in an EXCEL sheet and preferably presented in graphical form with respect of the theoretical nominal and tolerance.
- Remarks if applicable

This information is to be added in the PPAP.

Any deviation against the measurement method described underneath must be reported (in the TE EMEA dimensional report) and approved by TE engineering department.

3. GENERAL INFORMATION MEASURING ROOM

3.1 Measuring room conditions

Temperature: 20°C ±2°C

3.2 Measuring conditions

The product is measured on Measuring room conditions.
Therefor a climatization of minimum 24 hours in the measuring room of the product is recommended.

As contamination may influence the measurements, it is strongly adviced, before measurement:
- to clean the parts by filtered air pressure.
- to check the measurement equipment and probes.

4. GENERAL INFORMATION ON EQUIPMENT AND MEASUREMENT AGREEMENT

4.1 Justification

The figures in this measuring instruction can only be used as illustration of the text.
For the correct design, we refer to the drawing of each typical part.

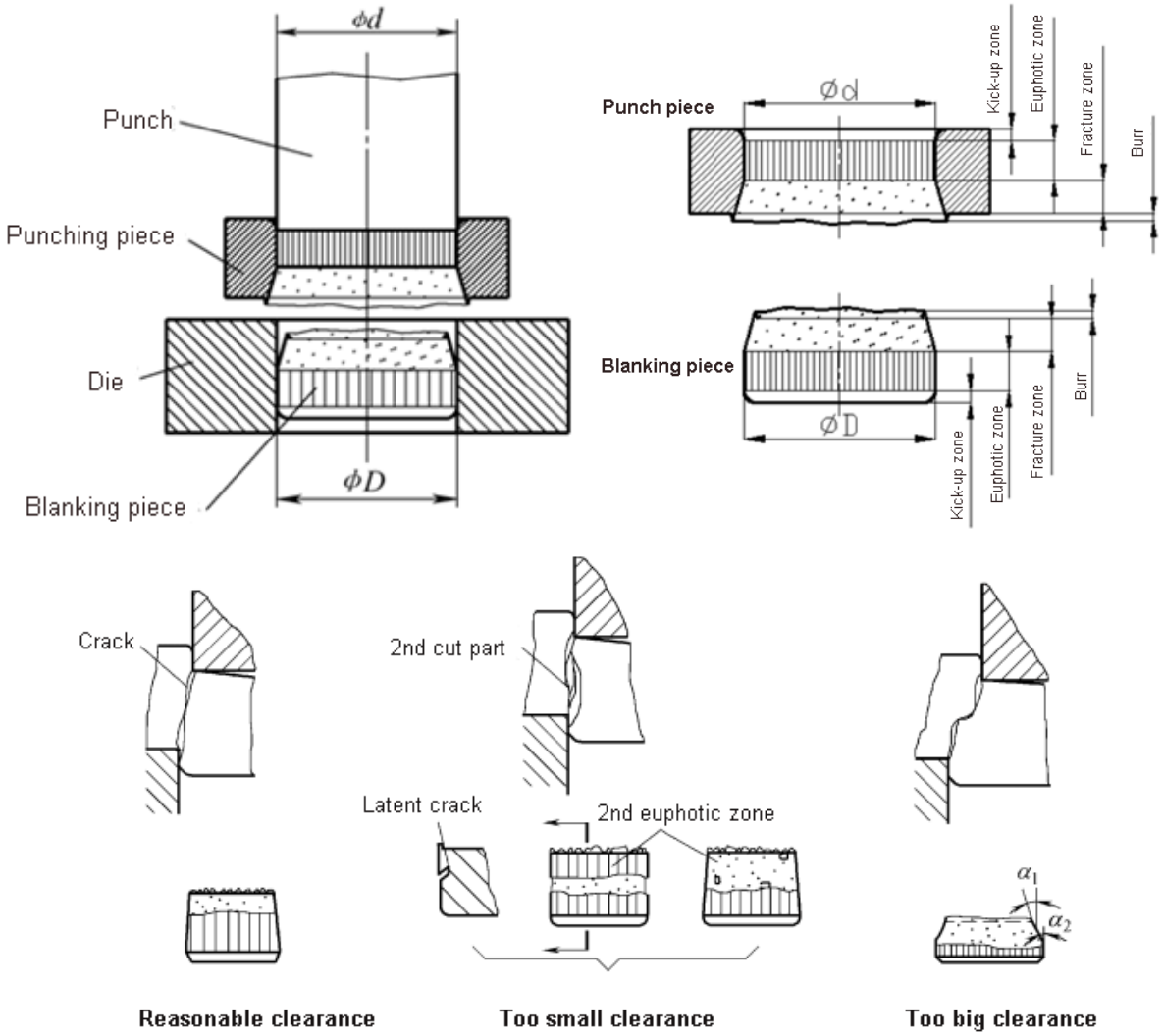
In order to perform a correct measurement, one has to taken into account the stamppacking process.

- The metal strip is going through the progressive die. Stamping the lamella corresponds with:
  - Punching piece: the geometry is formed by the punch, e.g. inner diameter
  - Blanking piece: the geometry is formed by the die plate
- The last step in the die is the stacking of lamellae with:
  - Interlockings: resulting in a press fit connection with the previous lamella (assembly)
  - Thru-holes: resulting in a parting from the previous stack (separation)
- The geometry is determined by many factors, such as the material properties, the clearance and the tool edge status or wear, the punching oil used.

The measurement should be made on the shear zone (= euphotic zone).

- The location of the shear zone (and burr side) is determined if the part is formed by the punch (punched piece) or the die plate (blanked piece).
- The use of a fixture, an appropriate choice of measurement probe, datums and measurement planes must eliminate measurement failures as much as possible.

Due to the accuracy and importance of the product, it is advisable to measure the product with a CMM.



https://www.machinemfg.com/metal-stamping-and-die-design-blanking/

4.2 Measurement Fixture

TE prefers and recommends the use of a fixture.

The fixture is a construction so that the part is in a non-clamped stable position.
If no fixture is used, it must be secured that the part is not moved during touching or scanning, i.e. when the part is touched by a probe during the execution of a program.
The use of rubber under the part can increase the stability during the measurement.

Remind that in any case (fixture or no fixture) the flat surface must avoid the influence of stamping burrs or rivets.

TE EMEA dimensional report:
Indicate if the measurement is made with fixture or no fixture. One can use the “Inspection Device Register”.
Please add a picture or drawing of the measurement set-up.

4.3 Measurement Probe and Stylus

TE requests to determine probe and stylus with a detailed investigation (see next sections) (e.g. MSA, measurement comparison).

For tactile measurements the preferred probe is a Renishaw system Low Force, with these properties:

- Probe Tip: sphere 2.0 mm diameter
- Stylus length: 50 mm / Stylus force: 20g
- Measured uncertainty of repeatability is less than ±0.08 µm (Renishaw specifications). Probe Test Certificate by Renishaw.

For more detailed measurements, the scanning probe SP25M + SM25-2 / SP25M + SM25-5 on a PH10M can be used.

TE EMEA dimensional report:
Indicate if the measurement probe used. One can use the “Inspection Device Register”

Ball material		Part number
Ruby		A-5003-0060
Silicon nitride		A-5004-1195
Zirconia		A-5003-6767
A	Ball dia. mm (in.)	4.0 (0.16)
B	Length mm (in.)	40.0 (1.58)
C	Stem dia. mm (in.)	2.0 (0.08)
D	EWL* mm (in.)	36.0 (1.42)
	Mass grammes	2.38
40 mm – 50 mm range		

4.4 Measurement Levels

The target is to measure in the shear zone, assumed to be the middle of each lamella.
The measurement level definition is:

- valid for both lamella material thickness used (0.35 ±8% or 0.5 ±6%):
- independent from the stamping process (punched or blanked piece)
- independent from the stacking process (lamella thickness, interlockings, interlamellar gap)

The measurement level is defined with this formula:

Measurement level (lamella N) = (nominal lamella thickness + 0,01) * (0,5+N-1) rounded to x.x mm

From the below tables, one can read the measurement level for each lamella:

Material thickness	**0,35**												
Lamella N	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Measurement level	0,2	0,5	0,9	1,3	1,6	2,0	2,3	2,7	3,1	3,4	3,8	4,1	4,5
Typical Drawing Datum (11 lamellae)			D= 0,9			E= 2			F= 3,1				
Typical Drawing Datum (13 lamellae Rotor)				D= 1,2			E= 2,3			F= 3,4			

Material thickness	**0,5**							
Lamella N	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Measurement level	0,3	0,8	1,3	1,8	2,3	2,8	3,3	3,8
Typical Drawing Datum (8 lamellae)		D= 0,8		E= 1,8		F= 2,8		

Remark: Use the Measurement Levels above as defined with the formula, also for drawings with D=1; E=2; F=3.

4.5 Measurement Points per measurement level

TE requests to determine the amount of measurement points with a detailed investigation. (e.g. MSA, measurement comparison).

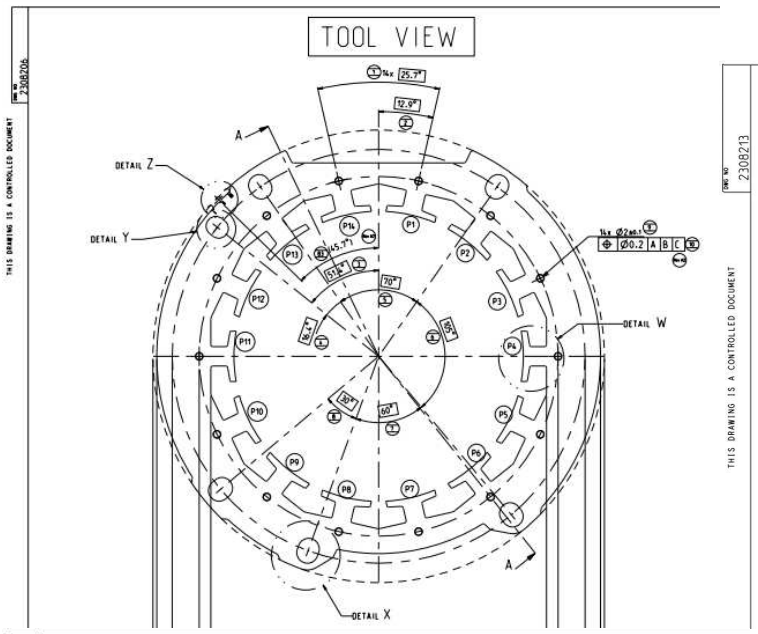
For the datums A, B and C the number of measurement points is defined on the drawing.

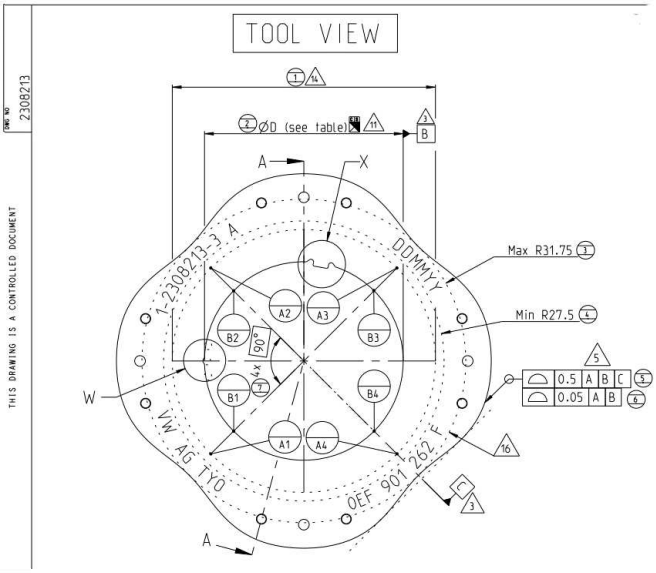
For the measurements the measuring technician must define enough measurement points to ensure a stable and accurate measurement.

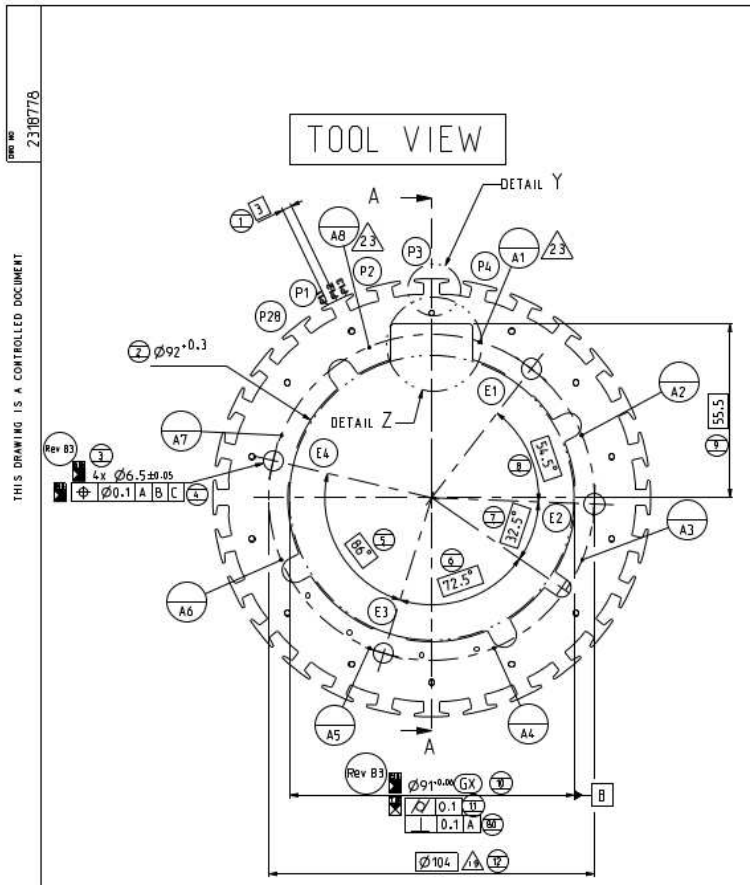
TE EMEA dimensional report:
Indicate the amount of measurement points.
One can use the Remark Metrology on “Dimensional Report” and also “Pictures”

4.6 Tool view and Pole numbering

- Tool View: the top view one has when looking to the die-plate of the tool, in other words when looking to the tool in the stamping direction of the punch. This drawing view is placed in the upper right corner of the drawing and indicated as “tool view”.
- Pole numbering: all poles are indicated on the Tool view, numbered clockwise.
- Remark that for the rotor the lobs are commonly not numbered.
- Remark that the pole numbers defined must be used for all parts in the following process steps, e.g. for the winding scheme.







5. RESOLVER ROTOR

5.1 Measurement set-up – Rotor

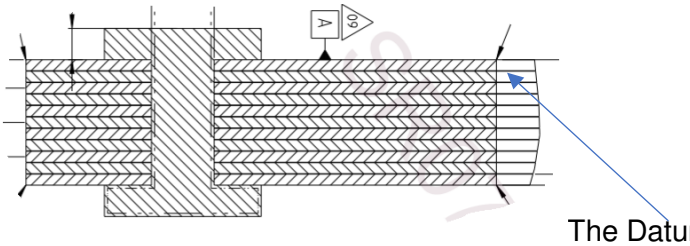
- All datum elements are defined on the top view of the part.
- Place the part on a flat surface with datum A facing up.
  In any case (fixture or no fixture) the flat surface must avoid the influence of stamping burrs or rivets.
- Fix the part e.g. with double sided tape, rubber, … to avoid part movement during measurement.

5.2 Datum A – Rotor

- The measuring points A1…An are defined on the drawing.
  At least 8 measuring points are recommended, distributed over a reference circle
- Make a pre-positioning measurement using the inner circle, to determine the location of A1…An.
- Construct Datum A as a gaussian plane from the measuring points A1…An.
- Set Datum A as pre-alignment for all following measurements.

5.3 Datum B – Rotor

- The measuring points B1…Bm are defined on the drawing.
  If the drawing states less than 8 measuring points, take 8 measuring points, else follow the drawing.
- Set the measurement level for the measuring points B1...Bm for
  - 0.35 mm lamella: on a level 0.18 mm below Datum A
  - 0.50 mm lamella: on a level 0.25 mm below Datum A
- Construct Datum B as a gaussian diameter from the measuring points B1…Bm.
- Project the center point of Datum B on Datum A for the measurements.



The Datum A-lamella is used for constructing Datum B

5.4 Datum C - Rotor

5.4.1 With keying feature (Tooth, Radius, …)

- Project the center point of the keying feature on the inside of the part on Datum A.
- Construct Datum C as an axis through the projected center points of datum B and the keying feature.
- Set Datum C as starting position (0°) of the measurements.

5.4.2 Without keying feature (Tooth, Radius, …)

Without keying feature, the definition of Datum C is difficult.
Alignment with Engineering is needed for the relative measurement against each other of:

- Contour
- Interlockings
- Rivets

5.5 Measurements (TE EMEA dimensional report)

5.5.1 Flatness of Datum A

Report the flatness of datum A even if this is not mentioned on the drawing.

5.5.2 Inner diameter / Outer diameter

For the measurement at least 8 points must be used.
Report the number of measurement points used. All individual values (x, y coordinates) must be provided.

Report the diameter with two measurement values (on each measurement level)

- GG (global gaussian circle) value
- acc. to the modifier mentioned on the drawing OR if no modifier is mentioned on the drawing:
  - GX (maximum inscribed circle) if rotor lobs are to the outside
  - GN (minimum circumscribed circle) if rotor lobs are to the inside

Report the inner diameter always on level E

Report the inner diameter on level D, E and F at PPAP submission and on request of TE
Report also the summarized value of the cylinder diameter containing all measurement levels D, E & F.

5.5.3 Contour

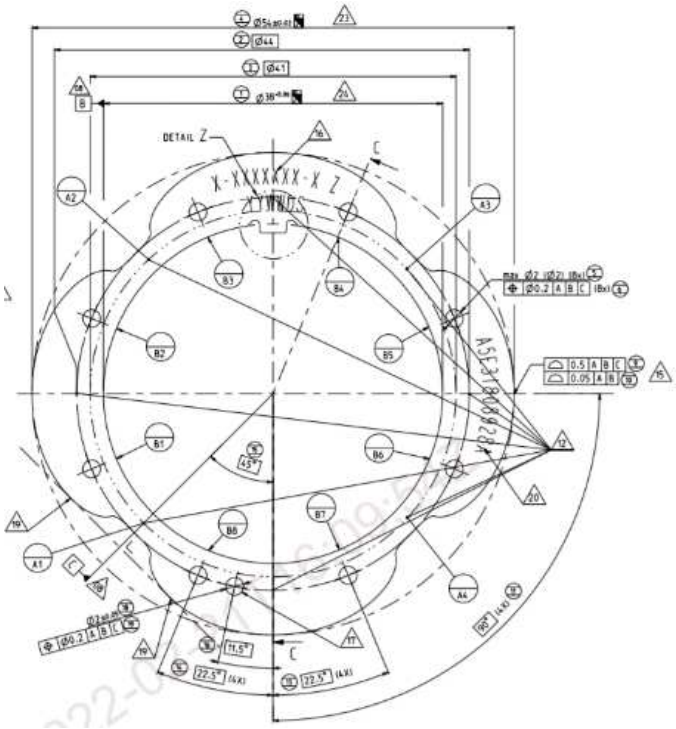
If scanning is used, please align with TE Engineering.
A scan report is needed.

If scanning is not possible, measurement on min 3 levels is needed.
Measuring must always be done perpendicular to Datum A.
All individual values (x, y coordinates) must be reported.

5.5.4 Capability

Capability is calculated on level E.
Capability is standard calculated on the GG diameter.
At best there is an alignment before measurement with TE engineering department.

Remark that the GPS-modifier is related to the diameter measurement only (see above) and not related to the capability calculation.



6. STATOR

6.1 Measurement set-up - Stator

- All datum elements are defined on the top view of the part.
- Place the part on a flat surface with datum A facing up.
  In any case (fixture or no fixture) the flat surface must avoid the influence of stamping burrs or rivets.
- Fix the part e.g. with double sided tape, rubber, … to avoid part movement during measurement.

6.2 Datum A – Stator

- The measuring points A1…An are defined on the drawing.
  At least 8 measuring points are recommended, distributed over a reference circle
- Make a pre-positioning measurement using the inner circle, to determine the location of A1…An.
- Construct Datum A as a gaussian plane from the measuring points A1…An.
- Set Datum A as pre-alignment for all following measurements.

6.3 Datum B – Stator

- The measuring points P1.2 … Pi.2 (=middle of each pole) are defined on the drawing.
  Each pole is considered for defining Datum B. Commonly there are 14, 16, 18, 28…. poles.
- Set the measurement level for the measuring points P1.2...Pi.2 for
  - 0.35 mm lamella: on a level 0.18 mm below Datum A
  - 0.50 mm lamella: on a level 0.25 mm below Datum A
- Construct Datum B as a gaussian diameter from the measuring points P1.2…Pi.2.
- Project the center point of Datum B on Datum A for the measurements.

6.4 Datum C – Stator

- Project the center point of the reference feature on Datum A.
- Construct Datum C as an axis through the projected center points of datum B and the feature.
- Set Datum C as starting position (0°) of the measurements.

6.5 Measurements (TE EMEA dimensional report)

6.5.1 Flatness of Datum A

Report the flatness of datum A even if this is not mentioned on the drawing.

6.5.2 Pole diameter

For the measurement three measurement points per pole Pi.1, Pi.2 and Pi.3 are used (see drawing).
All individual values (x, y coordinates) must be provided.

Report the diameter with two measurement values (on each measurement level)

- GG (global gaussian circle) value
- acc. to the modifier mentioned on the drawing OR if no modifier is mentioned on the drawing:
  - GX (maximum inscribed circle) if poles are to the inside
  - GN (minimum circumscribed circle) if poles are to the outside

Report the pole diameter always on level E

Report the pole diameter on level D, E and F at PPAP submission and on request of TE
Report also the summarized value of the cylinder diameter containing all measurement levels D, E & F.

6.5.3 Assembly diameter

For the measurement three measurement points per ear Ek.1, Ek.2 and Ek.3 are used (see drawing).
All individual values (x, y coordinates) must be provided.

Report the diameter with two measurement values (on each measurement level)

- GG (global gaussian circle) value
- acc. to the modifier mentioned on the drawing OR if no modifier is mentioned on the drawing:
  - GX (maximum inscribed circle) if ears are to the inside
  - GN (minimum circumscribed circle) if ears are to the outside

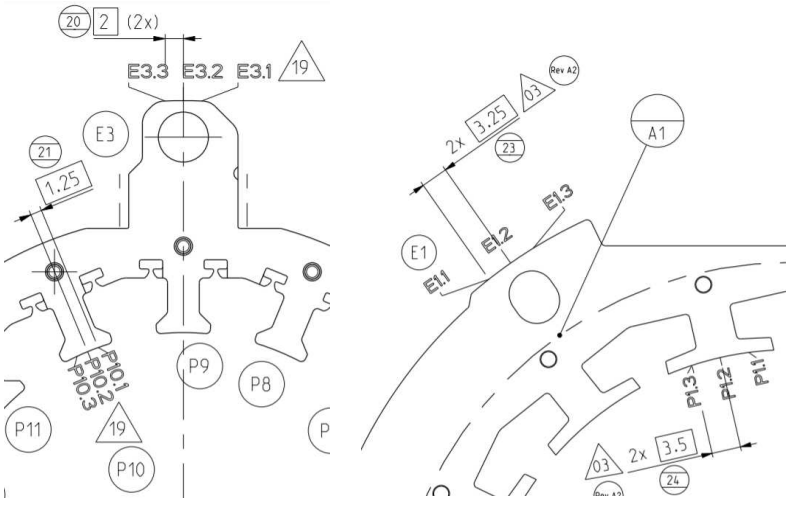
Report the assembly diameter always on level E

Report the assembly diameter on level D, E and F at PPAP submission and on request of TE
Report also the summarized value of the cylinder diameter containing all measurement levels D, E & F.

6.5.4 Capability

Capability is calculated on level E.
Capability is standard calculated on the GG diameter.
At best there is an alignment before measurement with TE engineering department.

Remark that the GPS-modifier is related to the diameter measurement only (see above) and not related to the capability calculation.

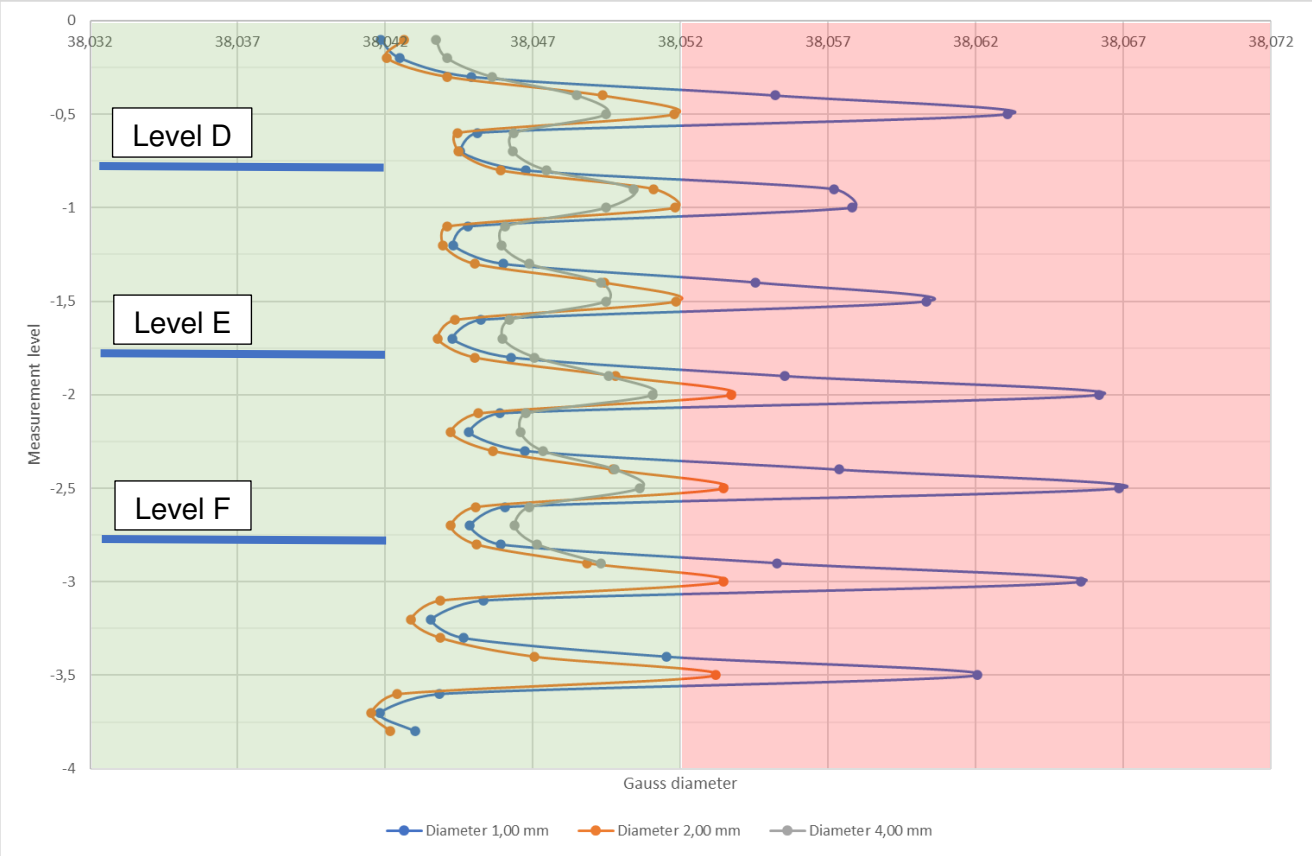


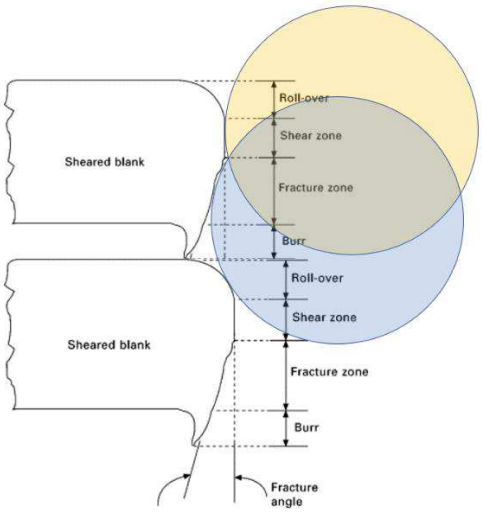
7. MEASUREMENT REMARK

7.1 Influence of the measurement probe

For example: measurement of inner diameter Ø38 +0.022/+0.052 with 8 lamellae of 0.5 ±6%.
Observation of the scanning results of the measurement over the stack height with:

- Probe Ø1,00:
  - The measurement is very sensitive. The range of measured values is large (~0,02mm) compared to the tolerance range of 0.03mm
  - The measurement level position may introduce a measurement failure.
- Probe Ø2,00:
  - The measurement failure of measurement on the shear zone or in-between-the lamellae is about 0.007, which is acceptable.
- Probe Ø4,00:
  - The measurement is very stable but incorrect.
  - The large probe sphere (compared to inner diameter) introduces a measurement failure.





7.2 Influence of the GPS-modifier

For example: measurement of inner diameter Ø38 +0.022/+0.052 with 8 lamellae of 0.5 ±6%.

The GN-diameter is constructed thru three maximum points measured.
In the below measurement, one can see that all three maximum points are in the same quadrant, resulting in a deviating GN-diameter. It is however obvious that this GN is not reflecting the reality.

	TE Part Number*		TE Tool Number*		TE Report #			Revision of Dimensional Report				Order #
	6-2334158-1 Rev. A		0		2241304M			1				2241304M
Position No.	Description	Nominal	Unit	USL (Tol+)	LSL (Tol-)	actual Dim. 1fach	Devia-tion 1fach	Alignment Description	Remark Metrology	Date of Measurement	Release PE	Criteria for Assessment and Release: - = Part conforms drawing Z = Deviation is accepted D = Drawing needs to be corrected E = Tool needs to be corrected V1 / V2 = Release with reservation (Refer the note in 'Release PE' for details) / Remark PE
2	D7											
2-1	GG	38,000	mm	0,052	0,022	38,044	-------+--		Werth Video Check	12/10/22		
2-2	GX	38,000	mm	0,052	0,022	38,028	--+-------		Werth Video Check	12/10/22		
2-3	GN	38,000	mm	0,052	0,022	38,080	0,028		Werth Video Check	12/10/22		
2-3'	GN (remeasured)	38,000	mm	0,052	0,022	38,085	0,033		Werth Video Check	13/10/22		see picture sheet