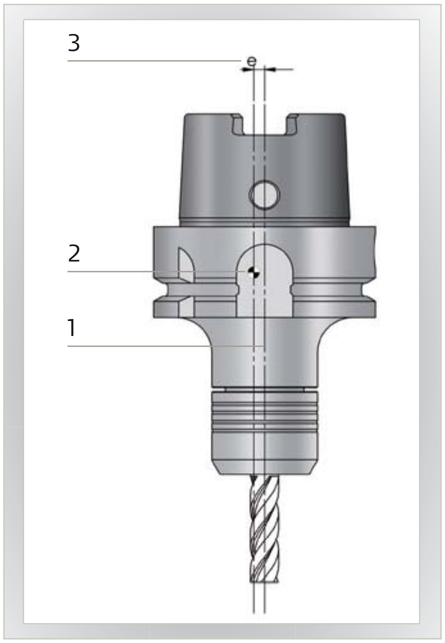
Technical Information | Balancing

Imbalance
- Rotor centre of gravity **2** is outside its rotational axis **1** (=offset e e **3**)



Causes
- Unsymmetrical bores and milling at the tool holder (e.g. taper shanks DIN 69871 and DIN 69893 HSK form A and B)
- Unsymmetrical shape of the tool (e.g. clamping surface at the milling cutter)
- Production tolerances (runout)
- Spindle runout

Consequences
Centrifugal forces cause vibrations. These cause:
- Damage to the spindle bearings
- Mediocre surface quality
- Insufficient repeatability of accuracy
- Reduction in tool life
- Noise

Requirements
Balancing is necessary whenever optimum working conditions have to be achieved e.g.
- Surface quality
- Production accuracies
- Tool operational life
- or if prescribed by the machine tool manufacturer (warranty claims!)

However, it is only economically sensible to balance at speeds of 8,000 r.p.m. or higher. At speeds lower than this the cutting forces are as a rule greater than the imbalance forces.

Balancing means – determining the centre of gravity axis and moving it back to the axis of rotation.

What Balance Grade
Our CENTRO|P precision collet chucks are fine balanced as standard. Information regarding the balance quality (in relation to the rpm or the minimum residual imbalance) you can find on the respective product page.

r.p.m. limits – Fine balancing in special execution is possible

Adaptation	Speed (up to / r.p.m.)	U	Information
HSK-25*	to 80.000 r.p.m.	≤ 1gmm	The max. speeds (additional fine balancing necessary) were recommended as guideline values as limit speeds for the HSK interfaces within the framework of HSK standardisation, as the speed has the greatest influence and is also the limit for spindle and spindle bearings. The max. rpm, however, should be adapted to the specific cutting process.
HSK-32*	to 50.000 r.p.m.	≤ 1gmm	
HSK-40*	to 42.000 r.p.m.	≤ 1gmm	
HSK-50*	to 30.000 r.p.m.	≤ 1gmm	
HSK-63	to 25.000 r.p.m.		
HSK-80	to 20.000 r.p.m.		
HSK-100	to 16.000 r.p.m.		
SK30*	to 20.000 r.p.m.		The values for chucks with taper shanks are empirical values which should not be exceeded (the values depend to a very great extent on the respective machine spindle)
SK40	to 20.000 r.p.m.		
SK50	to 16.000 r.p.m.		

No liability can be accepted for these specifications.
* All collet chucks with a total weight below 1kg → minimum residual imbalance

Please mind:
CENTRO|P types with long gauge length and a high length/diameter ratio (L/D) should not be run at maximum rpm. Please refer to our specific recommendations.

Limits to Balancing Grade

According to ISO standard 1940, the balancing standard is described using G. The balancing standard G corresponds to g/mmkg or µm and is in relation to the speed.

As an explanation: At a speed of 9,500 r.p.m and a weight of 1 kg G2.5 means a permissible offset between the rotational axis and the centre of gravity axis of the spindle of 2.5 µm. At a speed of 19,000 r.p.m. it would be 1.25 µm and at 38,000 r.p.m. 0.625 µm. If the tool holder together with the tool weighs half the amount, i.e. 0.5 kg, the balance will also be halved.

Until now, so as to minimise guarantee claims the machine or spindle manufacturers demanded such excessively fine balancing that their demands could only be met by balancing the chuck and the cutter on the machine spindle.

In order to avoid the high economic costs this caused, draft standard DIN 69888 covering balancing requirements on rotating tool systems was agreed jointly by the machine, spindle, balancing machine and tool manufacturers. The standard is expected to be adopted officially in 2007, and it is a sensible solution in both technical and economic terms, since in that norm all residual imbalances are indicated in „gmm“ and not assigned to a balance grade. Moreover, possible tool change faults are considered.

Grade steps to DIN ISO 1940-1

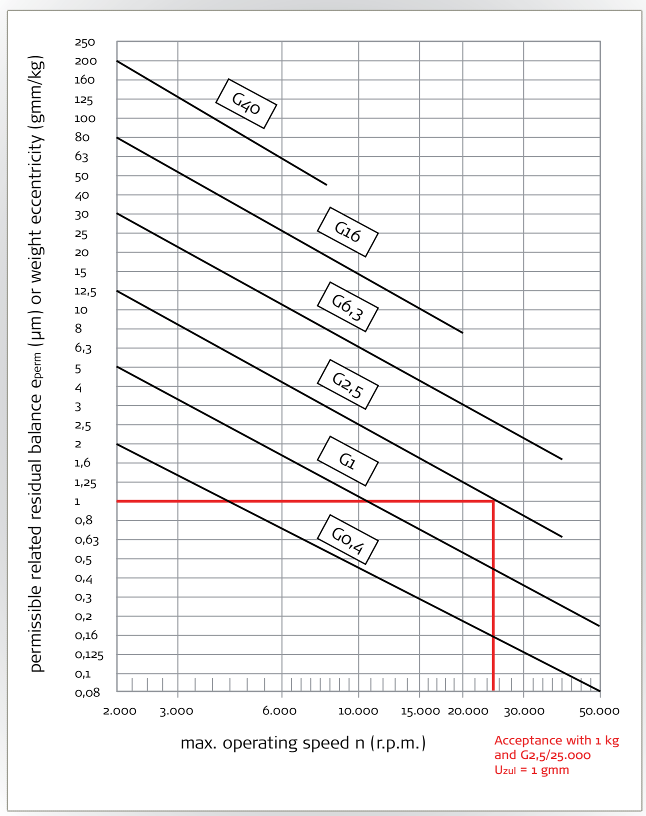
Permissible residual imbalances in relation to the balancing body weight for different grade steps G depending on the highest operating speed

General Formula

$$G = e \times \omega = \frac{U}{m_R} \times \frac{2 \times \pi \times n}{60} = \frac{U \times \pi \times n}{m_R \times 30}$$

then $$U = \frac{G \times m_R \times 30}{\pi \times n}$$

G = Balancing grade step	[mm/s]
e = Centre of gravity concentricity, related imbalance	[gmm/kg or µm]
n = Speed	[r.p.m.]
U = Imbalance	[gmm]
ω = Angular velocity	[1/sec]
m_R = Weight of the tool or the rotor	[g]



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Calculation of the total balancing grade of the assembled system (spindle • tool holder • tool)

Illustration of balancing grade total

$$U_{total} = U_{Spindle} + U_{Tool\ holder} + U_{Tool}$$

Example

$$U_{total} = U_{Spindle\ (G\ 0{,}4)} + U_{Tool\ holder\ (G2{,}5)} + U_{Tool\ (G6{,}3)}$$

Calculation of eccentricity

$$U = \frac{G \times 60}{2 \times \pi \times n} \times m$$

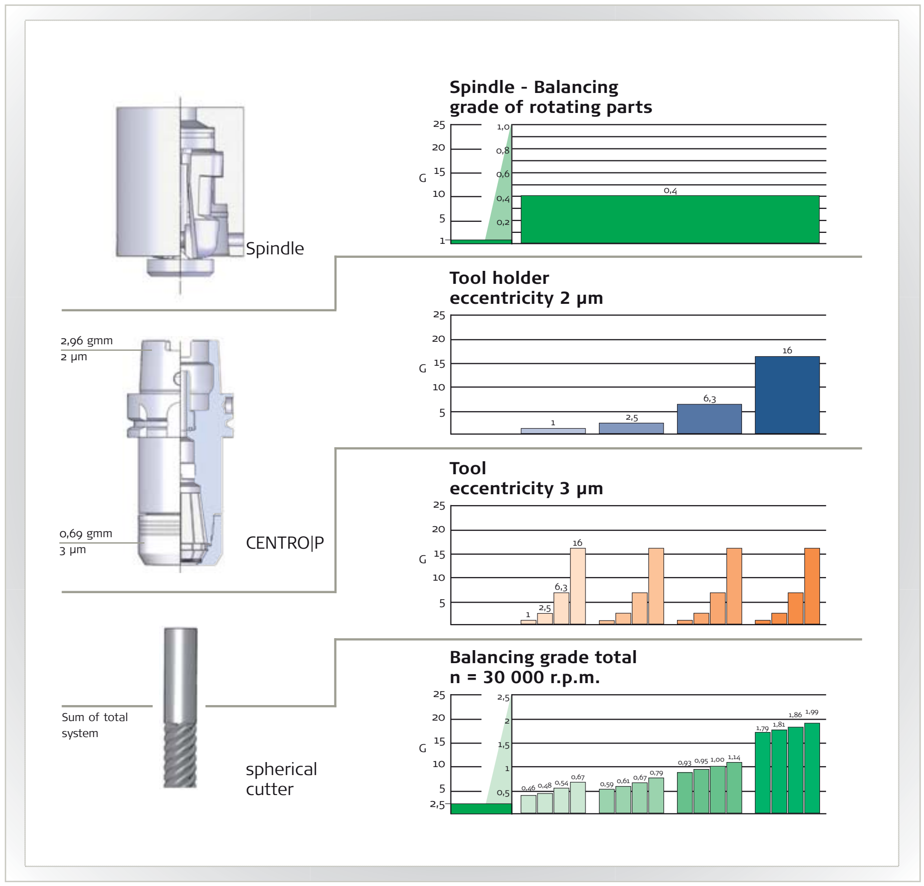
			m in g		U in gmm
$U_{Spindle}$	=	$\frac{0{,}4 \times 60}{2 \times \pi \times 30.000}$ x	15.000	=	1,910
$U_{Tool\ holder}$	=	$\frac{2{,}5 \times 60}{2 \times \pi \times 30.000}$ x	1.487	=	1,176
U_{Tool}	=	$\frac{6{,}3 \times 60}{2 \times \pi \times 30.000}$ x	230	=	0,461
			16.708 $m_{total\ in\ g}$		3,547 $U_{total\ in\ gmm}$

Balancing grade conversion of the total system

$$G = U_{total} \times 2 \times \pi \times \frac{n}{60 \times m_{total}}$$

Example

$$G = 3{,}547_{gmm} \times 2 \times \pi \times \frac{3.000 \times 1/min}{60s \times 16.708g} = 0{,}67$$



Calculation scheme with kind permission of Gühring oHG, Albstadt

Static or Dynamic Balancing
In practice balancing is very often carried out in one plane (Fig. 1). But the tool demonstrates only one centre of gravity error. The main axis of inertia and the rotational axis run in parallel to each other. This is known as “static” imbalance when the tool holder is relatively short in comparison with the diameter of the spindle holder.

In the case of long and thin tool holders balancing in two planes (Fig. 2) is sensible. In such cases, in addition to the existing centre of gravity error the main axis of inertia and the rotational axis no longer run in parallel to each other. This is known as a “dynamic” imbalance. The resulting imbalance moment generates a wobbling movement of the tool seat.

The following rule of thumb may act as a guide to whether the tool holder should be balanced as "static" or "dynamic":

Static balancing applies to tool holders
- which have an operating speed of less than 20,000 r.p.m.
- whose length (A) is less than double the diameter (D2)

Dynamic balancing applies to tool holders
- which have an operating speed over 20,000 r.p.m.
- whose length (A) is more than double the diameter (D2)

All single-cutter drilling and boring tools should be balanced in two planes.

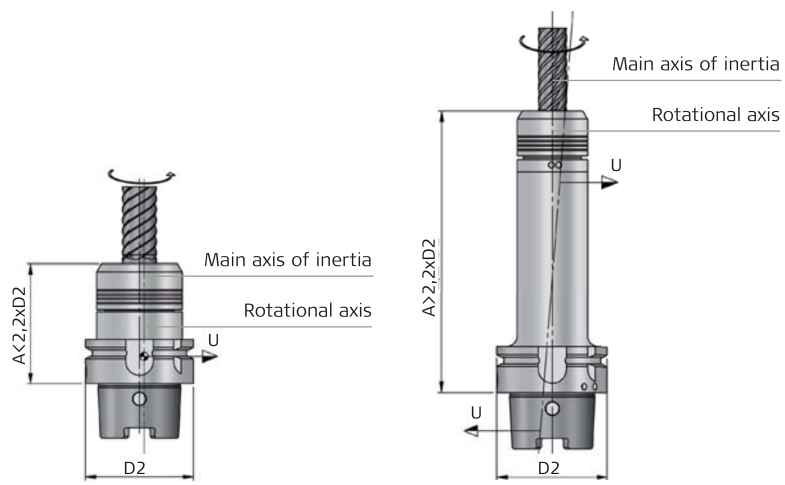


Fig. 1

„Static" imbalance in one plane

Fig. 2

„Dynamic" imbalance in two planes