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Shaking Cells: Orbit and Rate per Minute (RPM)

For the cultivation of mammalian cells in a TubeSpin® bioreactor TPP recommends a shaking diameter / orbit of D = 50 mm [1]. A larger diameter increases aeration, which is beneficial when working with shear-sensitive cells that require low shaking speeds, such as 150 rpm or less. [2] [3]

To switch between shakers with different orbits, the shaking speed must be adjusted to maintain the experimental conditions

Relative centrifugal force (RCF) is expressed as a multiple of the acceleration due to gravity (x g) and the speed in revolutions per minute (RPM). Relative centrifugal force is a function of radius and velocity.

Mathematical relationship:

Calculation of relative centrifugal force (RCF):

Relative centrifugal force (RCF) is calculated first with the given orbit r_1.

r = radius of the shaking diameter D in cm

$$\Rightarrow r = {}^{D}/_{2}$$

$$RCF = 1.118 \times 10^{-5} \times r_1 \times (RPM)^2$$

Calculation of RPM with new orbit r_2:

$$xRPM = \sqrt{\frac{RCF}{1.118 \times 10^{-5} \times r_2}}$$

Conversion Example:

Initially, a diameter of 50 and 180 rpm is used (shaker 1). What is the speed required to maintain the same experimental conditions if the orbit is changed by 30 mm?

Shaker 1:	Shaker 2:
Orbit D = 50 mm (→ r_1 =2.5 cm)	Orbit D = 30 mm (→ r_2 =1.5cm)
Speed = 180 RPM	Speed = x RPM

$$RCF = 1.118 \times 10^{-5} \times r_1 \times (RPM)^2$$

$$RCF = 1.118 \times 10^{-5} \times 2.5 \times (180)^2$$

$$RCF = 0{,}91$$

$$x\ RPM = \sqrt{\frac{0{,}91}{1.118 \times 10^{-5} \times 1.5}}$$

x = 232 RPM

The shaking speed (RPM) must be adjusted to 232 RPM when using a 30 mm orbit with the new incubator.

Important:

Always test:

- the influence of the shaking speed on cell growth or shear stress
- the optimum filling volume

Sources of information:
[1] TPP TechDoc
[2]https://handling-solutions.eppendorf.com/sample-handling/mix-shake/principles/detailview-principles/news/shaker-orbit-revolving-in-space-around-the-samples/
[3] Characterization of Gas-Liquid Mass Transfer Phenomena in Microtiter Plates. Hermann R., Lehmann M., Buechs, J. Biotechnology and Bioengineering (2003); Vol. 81, No. 2, pp 178-186
[4] https://www.sigmaaldrich.com/DE/de/support/calculators-and-apps/g-force-calculator

www.shakingtechnology.com