

The New Eppendorf X-Drive - Maximum Performance, Flexibility and Longevity for Demanding Shaker Tasks

Ines Hartmann¹, James Jarvis²

¹Eppendorf AG, ²Eppendorf Inc.

Executive Summary

Temperature controlled orbital shakers are indispensable for the cultivation of bacteria, yeast and other organisms grown in suspension. They are mandatory e.g. for the production of recombinant DNA, protein expression or screening of cultures. As a shaker is predominantly a shared device running 24/7 at high rpms and with variable load, it must be durable and reliable in operation. Most actual large incubated shakers can be triple stacked to save lab space but in this configuration speed is often limited. Moreover, an unevenly loaded platform or too heavy load can lead to disturbing vibrations which may impair

reproducibility. In worst case an out of balance situation results in an immediate stop of the shaker which means a stop of culture growth. The new Eppendorf Innova[®] S44i with the next-generation Eppendorf X-Drive offers maximum durability for all shaking loads up to 35 kg. With the integrated intelligent counterbalance adjustment function (Balance Master) the platform can be optimally balanced to all possible load and speed scenarios for best homogeneous and reproducible shaking and longevity of the shaker. There is no speed limit anymore in stacked configurations.

Introduction

Microbiologists and biotechnologists have been using orbital shakers to culture microorganisms since as early as 1950s. Freedman brothers built the first New Brunswick™ shaker for Dr. Salman Waksman laboratory from Rutgers University, USA, who was awarded the Nobel Prize in Medicine for developing the antibiotic Streptomycin. Since the introduction of molecular cloning techniques and the possibility to produce recombinant proteins in bacteria and other cells, today's lab environment from research to drug development are not imaginable without an orbital incubated shaker. Over the last decades' shakers were continuously improved offering today's flexibility in size, precise microprocessor controlled speed and temperature regulation.

The shaker - A versatile lab workhorse: Typically, when selecting an incubator shaker, a user looks for a device

that provides a specific temperature, speed and can carry a certain load. Most applications require the use of different vessel sizes and types: from plates for initial screening, to conical tubes for pre-cultures up to large flasks for plasmid production or protein expression. The constant need for producing higher product yields led to the invention of new flask types which increase aeration over standard shake flasks [1]. With this, typical filling volumes can rise also up to 40% leading to more weight on the platform. Higher speed ranges above 250 rpm are common for applications with e.g. *E. coli* to obtain significant increase in cell density. In conclusion, a shaker of today must be a versatile lab workhorse running 24/7 while bearing all sorts of platform configurations, loads and high speeds. Durability and robustness to provide reliable operation over years is important when selecting a shaker of today. But what makes a shaker a durable workhorse?

Solution & Benefits

Robustness of the drive: The drive is the heart of the shaker. It must move all points on the platform continuously in the same manner within the x-y plane in a circular movement to provide reproducible liquid movement. Different types of drives exist: a unicentric drive moves the platform on a single eccentric shaft [Figure 1 A]. Since its introduction, the cast iron Eppendorf triple-eccentric drive in the Innova product line, [Figure 1 B] has been the gold-standard in shaker drive technology and stands for robustness and reliable operation over years. It rotates the platform on three individual bearings and shafts giving more stability to the platform and longevity to the shaker. Eppendorf has now designed the next-generation shaker drive to offer maximum

performance, flexibility and longevity for demanding shaker tasks, the Eppendorf X-Drive [Figure 1 C]. The Eppendorf X-Drive components are fabricated to minimal tolerances ensuring stable, vibration-free operation. With its rigid central eccentric and the four corner support bearings it provides a highly precise and uniform circular motion at every point on the platform with an tight agitation control accuracy of ± 0.5 rpm. In contrast to the triple eccentric drive, the counterbalance can now be adjusted easily by the user with the integrated balance master function hence facilitating precise shaking of much higher loads than before and compared to competitive shakers [Table 1].

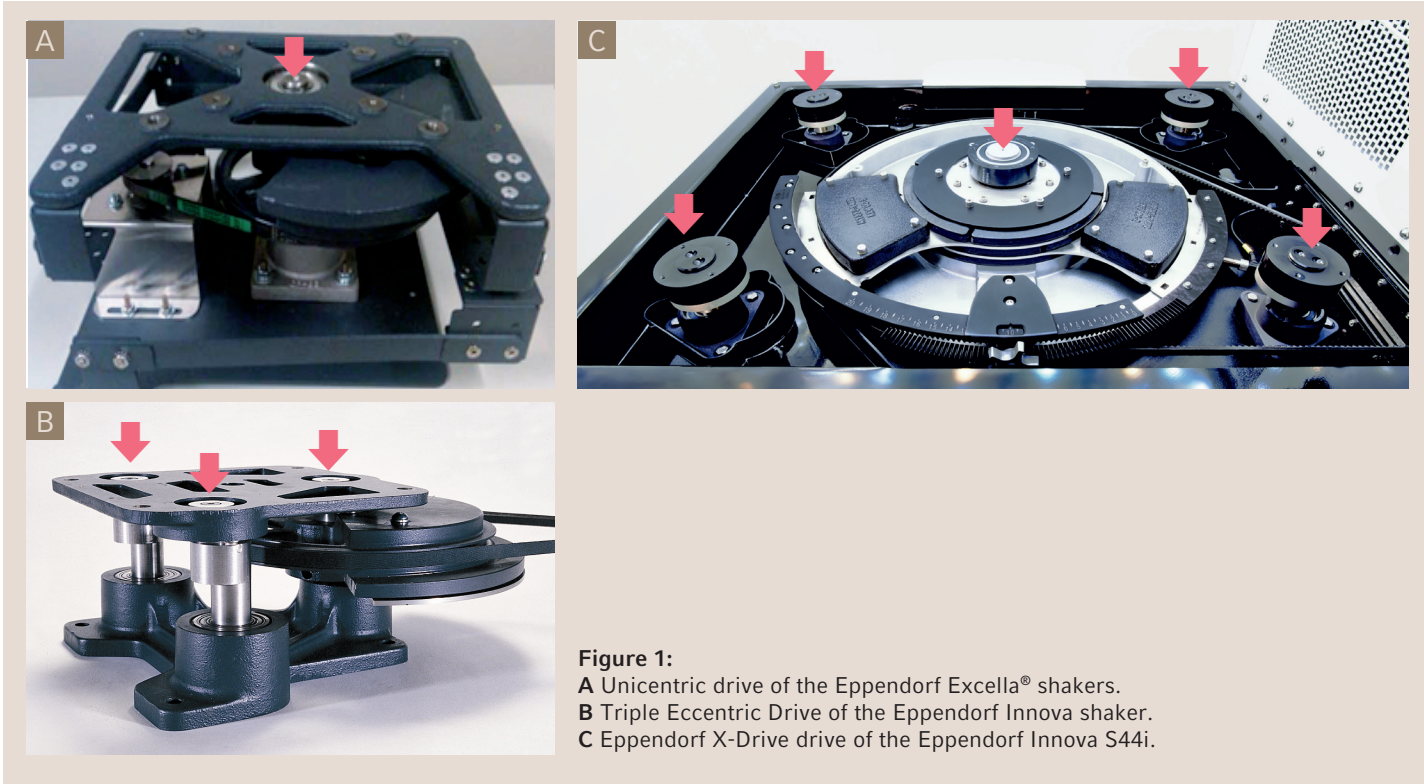




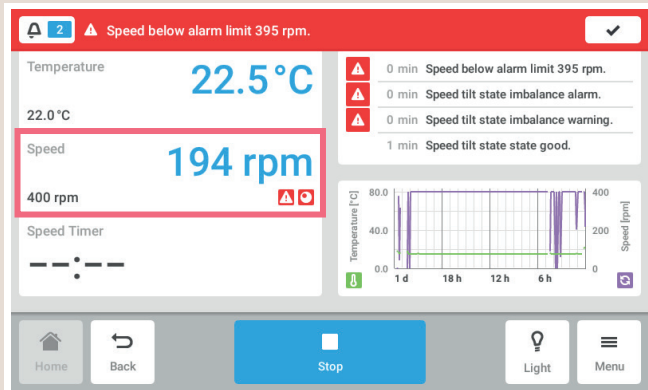
Figure 2:
A Innova S44i in double-stacked configuration.
B Universal platform loaded with various sizes of Erlenmeyer flasks.

Table 1: Load capacities on the perforated universal platform of different shakers (accessories not included) and limitations in speed in stacked configurations (according to technical information, *no information if with or without platform).

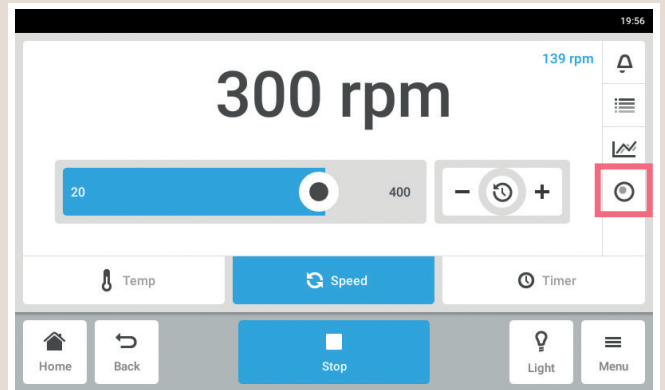
	S44i	Innova 44	Competitor I	Competitor T	Competitor K
Load	35.4 kg	19.5 kg	5.5–15.5 kg (depending on speed and orbit)	32 kg*	25 kg*
Speed limitation in stack	No limitation	2.5 cm orbit: 300 rpm for double stack 250 rpm for triple stack 5 cm orbit: 300 rpm for double stack 250 rpm for triple stack	2.5 cm orbit: 350 rpm for top unit in double stack 350 rpm for middle/top unit in triple stack 5 cm orbit: 250 rpm for top unit in double stack 20-250 rpm for middle / top unit in double stack	No limitation	No limitation

The Balance Master Function: The Balance Master sensing technology of the Eppendorf X-Drive ensures vibration-free shaking of any load and speed scenarios. With only one initial calibration of the Balance Master system during set-up, the shaker is optimized to work in its distinct configuration, e.g. as single unit or in the middle or on top of a triple stack. The shaker is optimized now to run smoothly and vibration-free for most of the shaking applications. The Eppendorf X-Drive’s integrated Balance Master Function measures continuously and in real time the vibrations on the platform. Possible imbalances, e.g. caused by very uneven

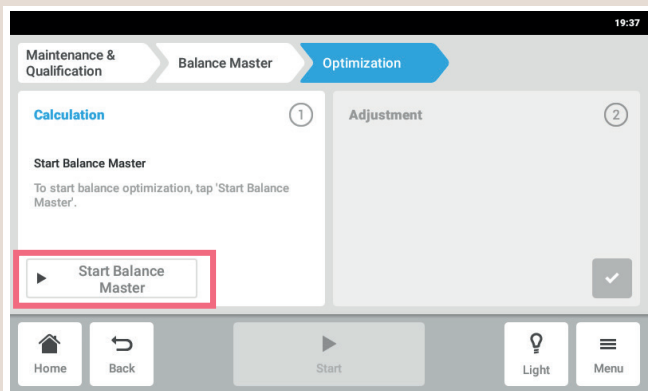
load distribution or extreme heavy loads, will be detected immediately by the system and the speed decelerates to a safe speed instead of stopping the device. The culture growth is not interrupted. The shaker notifies the user and provides step-by-step guidance to adjust the counterweight to run the shaker at the targeted speed [Balance Master Optimization, see Figure 3]. Balance Master assures that the shaker always runs smoothly no matter what load or speed is applied. And this assures proper, reproducible growth results and longevity of the shaker.



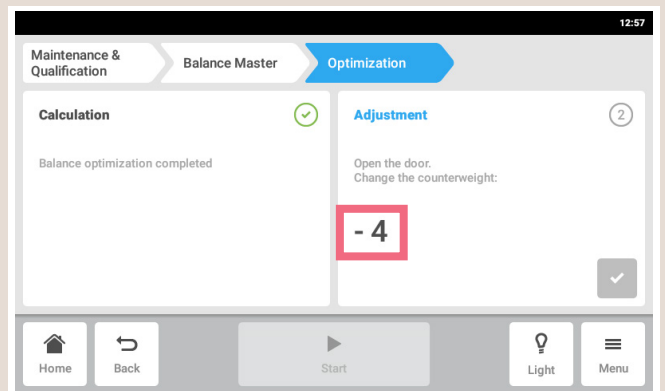
Balance master detects an out-of balance situation, decelerates speed and notifies the user.



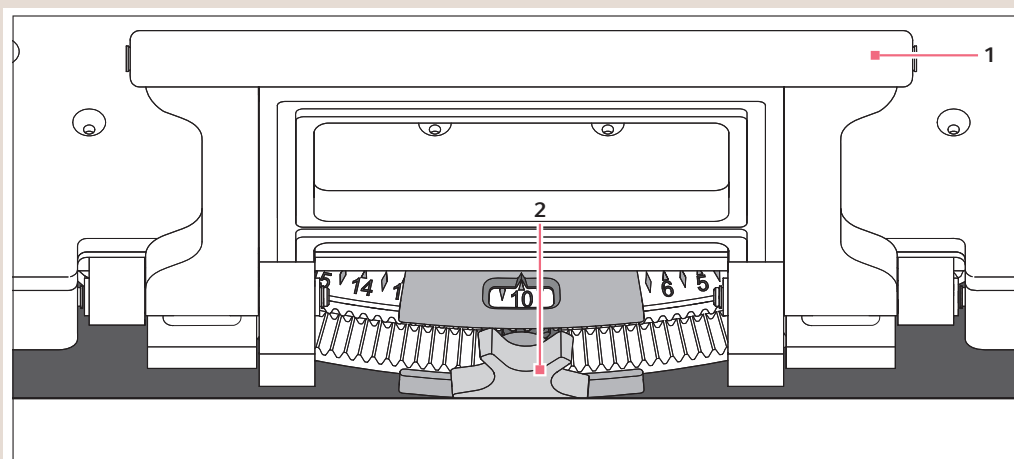
Step 1: Go to speed function and tap on Balance Master Optimization Icon if you want to adjust the counterweight to run the load at the targeted speed.



Step 2: Start Balance Master Optimization to detect the optimal counterweight position.



Step 3: Balance Master detects the optimal counterweight position and indicates the adjustment value in the end (here -4).



Step 4: Adjust counterweight manually by turning the counterweight adjustment knob in + or - direction. E.g. if the initial value was 10 and the new indicated value is -4 move the knob to position 6.

Figure 3: Balance Master Optimization: Process of optimization and counterweight adjustment in case of an imbalance situation. 1 = Sub-platform handle. 2 = Counterweight adjustment knob. The detailed process is described in the operating manual [2]

Platform capacity: With a more durable drive and the possibility to adjust counterbalance, the platform capacity can be expanded too. The Innova S44i offers the highest capacity compared to competitive shakers [Table 2] in both, universal and dedicated platforms. The Universal platform allows for mixing clamps of different sizes and other

accessories on a single platform and can also be used with sticky pads. Dedicated platforms come pre-installed with clamps of only one size. They will hold a greater number of flasks but do not offer the flexibility to mix other accessories. Easy access to the platform is provided by the slide-out platform function with quick-release handle [Figure 4].

Table 2: Maximum platform capacity for Erlenmeyer clamps on Universal and dedicated platforms of different shakers (according technical information) without installed options.

Universal Platform					
Erlenmeyer Size	S44i	Innova 44	Competitor I	Competitor T	Competitor K
125 ml	81	39	78 (100 ml)	39	50
250 mL	49	30	45	30	40
500 mL	36	24	27	24	27
1 L	20	14	18	12	16
2 L	13	8	11	11	9
2.8 L Fernbach	8	6	7	6	5
3 L	8	6	8	No fit of clamps > 2.8 L	8
4 L	8	6	7		5
5 L	6	6	5		5

Dedicated Platform					
Erlenmeyer Size	S44i	Innova 44	Competitor I	Competitor T	Competitor K
125 ml	86	60	/	61	60
250 mL	53	40	48	40	40
500 mL	39	24	31	24	26
1 L	23	15	19	15	16
2 L	15	12	13	12	9
2.8 L Fernbach	8	6	/	6	/
3 L	/	/	9	No fit for clamps >2.8 L	8
4 L	8	6	8		5
5 L	/	/	6		4

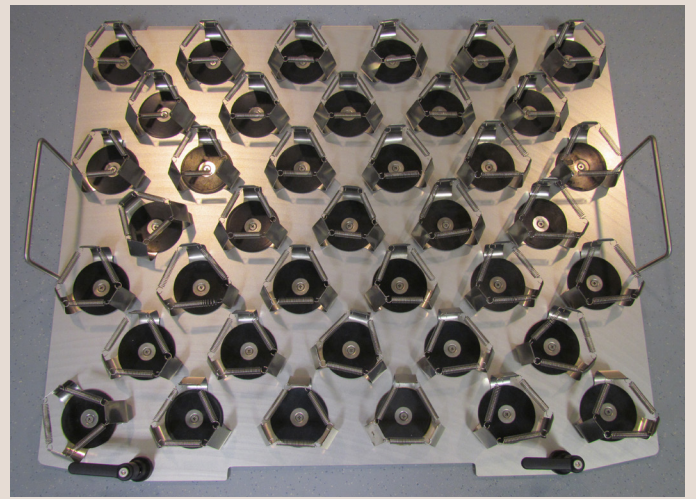
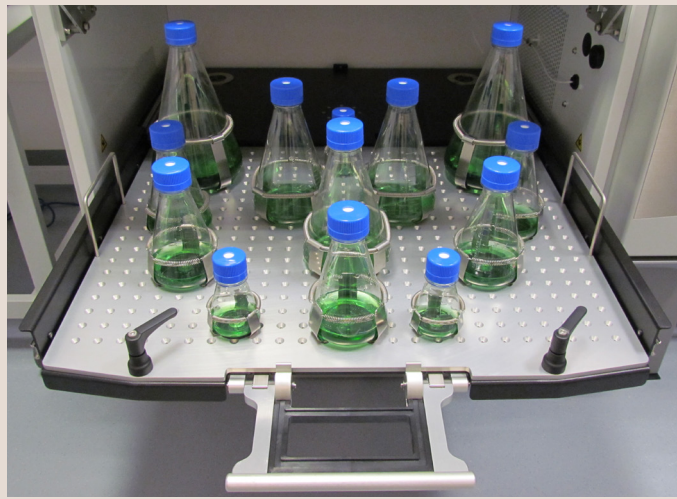


Figure 4: A Universal platform for flexible placement of multiple accessory formats. The slide-out mechanism allows easy access to flasks. B Example of a dedicated platform, which comes pre-mounted with one size of clamp.

Summary

In conclusion, the high capacity Eppendorf Innova S44i is perfectly suited for all microbiology shaking applications providing years of reliable operation. With the new Eppendorf X-Drive, the shaker can now bear a heavier weight load and more vessels on the platform with the highly uniform shaking performance of the Innova shakers. The integrated balance master function with real-time sensing technology gives the user maximum 'peace of mind' that the shaker runs smoothly. With the option to adjust the counterbalance there is hardly a limit in load scenarios anymore.

[1] Thomson Ultra Yield™ Flasks. <https://htslabs.com/uyl/>

[2] Operating Manual Eppendorf Innova S44i. www.eppendorf.com

About Eppendorf

Eppendorf is a leading life science company that develops and sells instruments, consumables, and services for liquid-, sample-, and cell handling in laboratories worldwide. Its product range includes pipettes and automated pipetting systems, dispensers, centrifuges, mixers, spectrometers, and DNA amplification equipment as well as ultra-low temperature freezers, fermentors, bioreactors, CO₂ incubators, shakers, and cell manipulation systems. Associated consumables like pipette tips, test tubes, microtiter plates, and disposable bioreactors complement the instruments for highest quality workflow solutions.

Eppendorf was founded in Hamburg, Germany in 1945 and has more than 3,000 employees worldwide. The company has subsidiaries in 25 countries and is represented in all other markets by distributors.

Your local distributor: www.eppendorf.com/contact

Eppendorf AG · Barkhausenweg 1 · 22331 Hamburg · Germany
eppendorf@eppendorf.com · www.eppendorf.com

www.eppendorf.com