epGreen®

Guide Centrifuges

Efficiency demands Performance

Power consumption - energy saving while spinning

Abstract

Beyond classical features like silence, speed, and simplicity, centrifuges nowadays are accompanied by green topics like power consumption, energy saving, and reduced consumption of resources during production. In this guide, we present several topics related to the low power consumption of Eppendorf centrifuges in respect to generational change, standby consumption, rotor weight, FastTemp pro, or power consumption per tube.

Introduction

One of the most serious contributions to greenhouse gas emission results from the energy consumption of products over time. Therefore, we focus on developing new product features that reduce the energy required to operate our products.

Eppendorf centrifuges go beyond speed and capacity to benefit the customer and the environment. In addition to the speed, capacity, and versatility you need for all your applications, Eppendorf centrifuges also offer:

- unparalleled ergonomic operation (e.g., extremely low noise levels, soft-touch one-finger lid closures, very low profiles for easy loading/ unloading),
- advanced temperature management for maximum sample protection and energy-savings (e.g., dynamic compressor control (DCC), high temperature accuracy, ECO shut-off).
- With their outstanding quality and longevity Eppendorf centrifuges are the cost efficient solution for your lab.

epGreen

Eppendorf recognizes what it means to go “green” by focusing on the development of new features to constantly reduce the energy consumption and to optimize the environmental impact of our business operations and the products we produce.

None of these challenges can be solved quickly or easily. But all of them demand that we listen to one another and work together. That we focus on caring for the environment and the future of all of us.
We know where that road leads: The reduction of your CO_2 footprint becomes our mission.
In accordance with this goal, Eppendorf has decided that newly developed products have to focus on reduced energy consumption, for production as well as at your lab bench. This work is never over. That’s why, at Eppendorf, we started to focus on completely new technologies in respect to epGreen. All of us have to change, to adapt to new technologies to fill the gaps in environment saving we still have. As centrifuges run only several minutes to hours per day, their power consumption is lower than for devices with 24 h per day running time (freezers, biosafety cabinets, incubators, etc). Nevertheless, by applying new, innovative technology, the power consumption of centrifuges can be optimized.
Even improvements at already low consumption levels do benefit the environment. We must pursue every opportunity for progress.

Still, we do not compromise in respect to sample safety, meaning, we insist on exact temperature conditions for your samples. For example, when you put the setting to 4 °C for a spinning run of highly sensitive protein samples, you have the right to expect temperature accuracy. Temperature accuracy is directly related to reproducibility and data reliability.

eppendorf

Our goal for your equipment:
Optimized motor systems, light weight rotors, and highly efficient compressor systems for optimized cooling in combination with low energy consumption – as efficiency demands performance.
We will help you to make this journey.

Manufacturing & Logistics

Environment-protection (incl. power saving) already starts during development and manufacturing of products. Within the last 10 years, our centrifuge facility reduced the electrical power consumption per produced centrifuge by more than 50 %.
The centrifuge production site in Germany is already certified according to ISO/EN 14001, which represents the core sets for an effective environmental management system.

Saving of resources:
During production of metal parts, corners and curbs have to be rounded. This beveling process must be continuously cooled by water to avoid over-heating of the process. Instead of disposing the sewage water, our production team recently developed a system to recover up to 95 % of the involved water. The nearly closed cycle saves now one of the main natural resources: clean drinking water.
The Eppendorf fixed-angle rotors are made of pure aluminum. When milling the shape of the rotor and generating the bores during the production process, all chippings are collected. The generated swarf material is a high grade resource for recycling processes. The metal routed out of your roughly forged rotor might be the starting point for another set of rotors.

Rotor chambers of refrigerated centrifuges are insulated by a special insulation foam for optimal temperature control. By creating new chemical formulas, the thermal conductivity of the foam was now reduced considerably. Meaning, the same thickness of foam results in a much better insulation. This improvement of the insulation is the cutting edge for providing the temperature accuracy of Eppendorf refrigerated centrifuges nowadays – in combination with a remarkable low power consumption.

Reduction of emission:
One green goal during production is the distinct reduction of using organic solvents which are harmful to the environment.
The compressor system of a centrifuge contains a vaporizer that converts the cooling liquid into the gas phase, when low temperatures have to be reached. During production of such a vaporizer, separation agents are needed that contain solvents. Recently, the amount of these solvents was reduced by up to 60 %.

For the temperature accuracy within the rotor chamber of refrigerated centrifuges, a foam insulation encloses the chamber. In general, special separating agents are used in the production process of the foam, containing a major organic solvent part and an aqueous part. Based on in-house research work, we were able to reduce the organic fraction explicitly by up to 70 %, shifting the major volume part from the organic liquid to the aqueous liquid.

Cooling liquids in the past contained CFC (chlorofluorocarbon), an organic compound, containing chlorine, fluorine, and a carbon backbone. As they contribute to ozone depletion, CFC is exchanged by other cooling liquids. The cooling liquid of the Eppendorf centrifuges is a CFC-free refrigerant with an ozone depletion potential of zero.

All Eppendorf production sites have switched to water soluble varnishes and paints.

Transporting increases the product carbon footprint. Each 650 km of air transport or 8,000 km of sea transport will increase the carbon footprint by an extra kg of CO_2 per kg of product. Thus, sea freight is almost 10 times less polluting than air freight.
Since 2005, Eppendorf has therefore reduced air freight by more than 60 %.

Generational change

With our new generation of microcentrifuges, we significantly reduced the power consumption for the centrifugation process compared to the precursors.

Figure 1:
18-place centrifuge
From Centrifuge 5415 C to Centrifuge 5418
-> Reduction of up to 25 % of power consumption for spinning (Several test runs per centrifuge type (16,000 x *g*, 20 min, room temperature)).

Figure 2:
24-place centrifuge
From Centrifuge 5415 D to Centrifuge 5424
-> Reduction of up to 8 % of power consumption for spinning (Several test runs per centrifuge type (16,000 x *g*, 20 min, room temperature)).

By using more efficient engines for the spinning process, we were able to reduce the power consumption for the pure spinning process by up to 25 % reduction for the 18-place centrifuge and by up to 8 % reduction for the 24-place centrifuge.

Figure 3:
24-place refrigerated centrifuge.
From Centrifuge 5415 R to Centrifuge 5424 R
-> Reduction of up to 60 % of power consumption for FastTemp run
-> Reduction of up to 20 % of power consumption for 17 h (over night) continuous cooling.

By introducing highly efficient cooling systems, the power consumption of the 24-place refrigerated centrifuges was reduced by up to 60 % for the FastTemp function as well as up to 20 % for the over night continuous cooling.

Baseline consumption

Only in few labs, all devices are constantly switched off in the evening. Midterm, this results in high power consumptions as the devices remain ready-to-use. The consumption is even higher for the weekend.
In general, we reduced the baseline power consumption with the current microcentrifuge product lines compared to the previous generation.

- From Centrifuge 5415 C to Centrifuge 5418: Reduction of baseline consumption up to 70 %
- From Centrifuge 5415 D to Centrifuge 5424: Reduction of baseline consumption up to 65 %
- From Centrifuge 5415 R to Centrifuge 5424 R: Reduction of baseline consumption up to 25 %

Standby

As a further step into energy saving, Eppendorf decided to integrate more and more power saving functions in the centrifuges.
The standby power consumption is that amount of power which is consumed when the device is switched off (still plugged in), or when it remained in a sleep-mode.
The Centrifuge 5418 and Centrifuge 5424/ R automatically switch into standby mode after 15 min of non-use, the display is then reduced to the “ep” sign.
For the flagship of our microcentrifuges, the Centrifuge 5430/ R, you can even set the time after which the centrifuge should automatically change to the standby mode (1 to 60 min).

Figure 4: Centrifuge 5430 R with smart electronic for power saving

ECO shut-off

Most refrigerated Eppendorf centrifuges are already equipped with an ECO shut-off function. This means, the compressor is shut off automatically after 8 h of non-use of the centrifuge to save power and to prolong the lifetime of the compressor.
(ECO shut-off of all current refrigerated Eppendorf centrifuges: after 8 h; Centrifuge 5417 R: after 6 h)
You can switch off this function for continuous cooling if needed for sample safety.

Lightweight rotor

Ever seen the inside of an airfoil? Made of aluminum, light weight and filigree structures combined with extreme stability. The inside design of the high-volume fixed-angle rotors (F-34-6-38 and FA-45-6-30) is optimized in a similar way: All metal that is not needed for safety or performance is routed out to significantly reduce the rotor weight.
The resulting rotor designs are among the lightest in the industry and provide significant improvements regarding handling, operational safety, and eco-friendliness.
The lower the weight, the lower the energy consumption during spinning and especially during the acceleration and deceleration.

Figure 5:
Cut-mockup of high volume fixed-angle rotor F-34-6-38

FastTemp

For sure you have already experienced the following situation before: You are entering the lab in the morning and one centrifuge is still in the refrigerated mode with continuous cooling turned on. Someone did a FastTemp run the late afternoon before and forgot the machine. Or the colleague wanted to have a cooled machine for early beginning in the following morning.

Figure 6:
FastTemp button

The FastTemp function, also known as “FastCool” or “Pre-Cool” is commonly known. This FastTemp function with its pre-cooling program is nowadays standard for refrigerated centrifuges.
The drawbacks of the situation mentioned above are: As the compressor works throughout the whole night, this reduces the life time of the compressor. Besides that, your centrifuge consumes an unnecessary high amount of power over night.

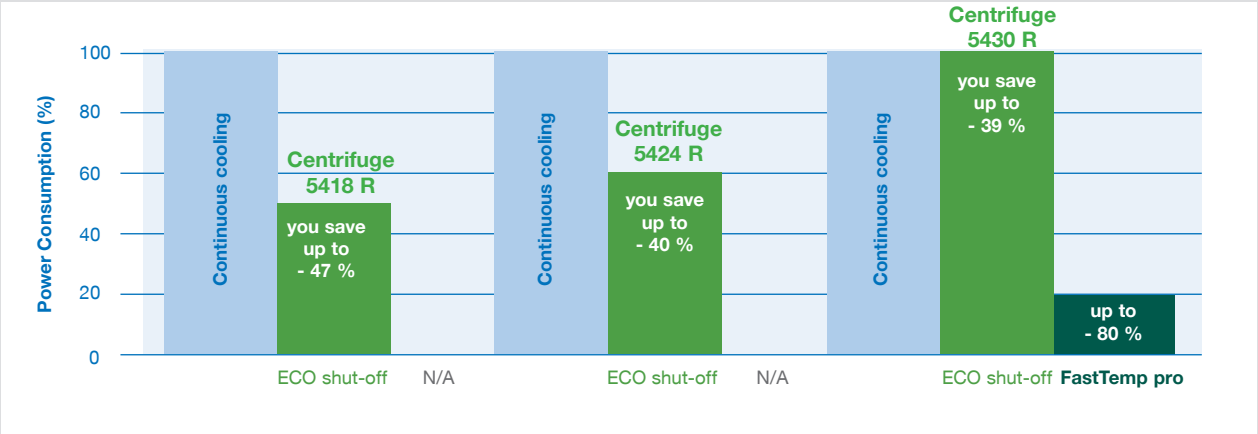
Keeping also the forgetful folks in the lab in mind, the Eppendorf refrigerated centrifuges are equipped with an ECO shut-off, e.g., the compressor is automatically shut down after 8 h and the machine switches into standby mode (reversible). Power is saved, and your compressor will have a longer life time.

FastTemp pro

We took what was good and made it better
To optimize the power-consumption and enable a much more user-friendly interaction, our engineers improved this FastTemp function: The FastTemp pro function of the Centrifuge 5430 R enables programming the temperature control run with defined start times (date + time + temperature). Just put the centrifuge into energy-saving standby mode before you leave the lab in the evening.
The centrifuge will restart from standby mode on its own at the pre-selected time point in the morning and pre-cool the chamber and the rotor.

In Table 1 we present the power consumption data comparing the FastTemp function including continuous cooling over night (17 hours) with the ECO shut-off function (Centrifuge 5418 R, 5424 R, 5430 R) and the FastTemp pro function of the Centrifuge 5430 R.

Table 1: Power Consumption of Centrifuge 5418 R, 5424 R, and 5430 R



Comparing continuous cooling, ECO shut-off, and FastTemp pro. (N/A: not applicable)

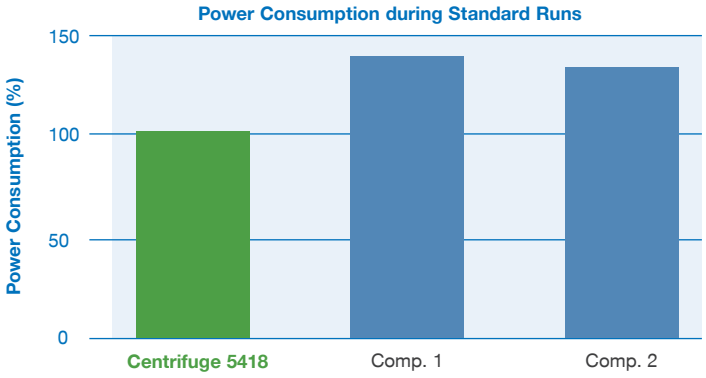
There are two effects demonstrated by Table 1: On the one hand, the ECO shut-off function saves up more than 40 % of power compared to continuous cooling over night for all those machines which were not actively switched into standby mode at quitting time.
On the other hand, all those users who need a pre-cooled centrifuge in the morning should prefer the FastTemp pro effect of the Centrifuge 5430 R. The much lower power consumption for standby in combination with FastTemp pro is a clear advantage in contrast to the continuous cooling over night (80 % less than continuous cooling).

Eppendorf refrigerated centrifuges also feature a dynamic compressor control for optimized cooling performance, extended compressor life, and reduced energy consumption in total.

Power consumption during standard runs

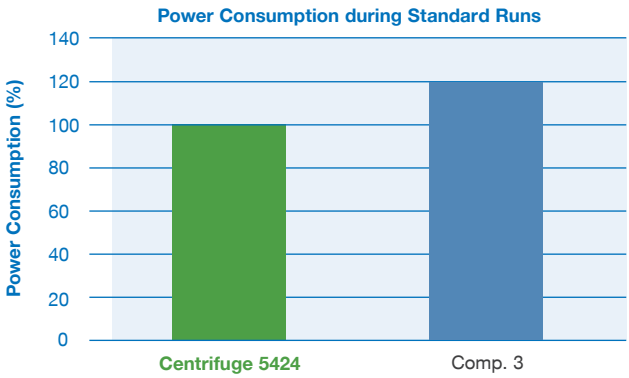
For some standard microcentrifuges, we compared the power consumption for typical runs in a lab. With the given devices, we got the following results when comparing similar centrifuge classes (Table 2-4):

Table 2: Non-refrigerated personal centrifuges (220 V)



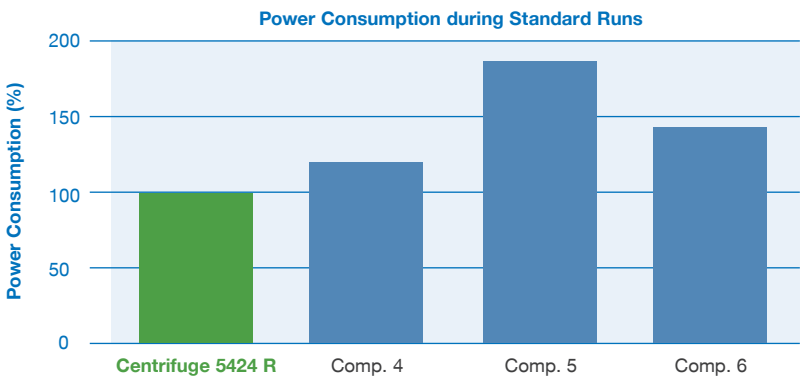
16,000 x g, 60 min, room temperature, 10x 1.5 mL microtubes with 1,000 µL water each

Table 3: Non-refrigerated 24-place centrifuges (220 V)



20,000 x *g*, 60 min, room temperature, 10x 1.5 mL microtubes with 1,000 µL water each

Table 4: Refrigerated 24-place centrifuges (220 V)



20,000 x *g*; 60 min; 4 °C; 10x 1.5 mL microtubes with 1,000 µL water each; FastTemp run before

Within the class of compact personal benchtop centrifuges with average speed of 16,000 x *g*, the Centrifuge 5418 clearly shows its advanced power consumption system. Besides the low noise level of the OptiBowl system, the Quicklock rotor lid, and the compact footprint for less bench space, the low power consumption of the Centrifuge 5418 is one of the major benefits for the user. The middle class Centrifuge 5424 as well as the refrigerated counterpart Centrifuge 5424 R have very low power consumptions during standard runs.

Power consumption per tube

Comparable to gas consumption of cars (consumption per 100 km or miles per gallon), there are several ways to compare the eco-concept of centrifuges. One way is to display the power consumption per tube.

A device running with maximum amount of tubes and maximum loading of each tube is assumed. The consumed power is divided by the number of tubes.

Figure 7: High capacity rotor A-4-81

As a matter of fact, such values do not reflect the reality in routine/ research laboratories. In reality, a user has to process upcoming samples directly to save time and money in the workflow of his lab. It is quite rare at once to wait until the sample accumulation fills the centrifuge to 100 % - only to save power while wasting time.

In conclusion: The sometimes displayed power consumption per tube displays only a theoretical value.

In general, you need to differentiate between the nominal value of the power supply unit and the real power consumption. Technically spoken, the nominal value of the power supply unit is the maximum continuous rating of this unit. This nominal value is listed on the identification plate of the device (Figure 8). For example, the power supply unit of the Centrifuge 5810 R is capable to supply up to 1,650 W (per hour).

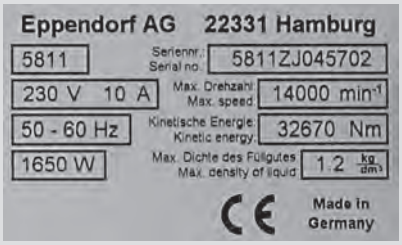


Figure 8: Nominal value of power supply of Centrifuge 5810 R: 1,650 W (per hour)

This maximum continuous rating for all electronical devices corresponds to the most extreme load that is possible. The security system of each instrument is developed according to this maximum value. Regarding centrifuges, the most extreme load would include:

- start of run at maximum room temperature, the device can withstand (e.g., 40 °C) plus
- application of maximum cooling/ heating to reach the lowest/ highest temperature that is possible in rotor and sample plus
- the usage of the heaviest rotor possible plus
- a full loading of the rotor plus
- a run at maximum speed plus
- the application of samples with highest density possible (1.2 g/ mL)

An experienced lab worker will realize soon that a centrifuge indeed sometimes scratches some of its limits, but nearly never all - in one and the same run.
Summarizing, it does mean, that the device just needs a part of this maximum continuous rating during normal usage, e.g., for spinning and cooling.

As a matter of fact, the real power consumption of a device is lower than the maximum continuous rating. The real power consumption differs between applications. It is not a fixed value, such data must be measured – on-line.

When checking the nominal value calculation (see Table 5), the power supply unit of the Centrifuge 5810 R (1,650 W) would result in 59 Wh/ tube, when spinning 28 tubes for 1 h.

A comparable competitor device has a power supply unit with a maximum continuous rating of 1,950 W (per hour), resulting in 69 Wh/ tube, when spinning 28 tubes. When using the maximum capacity of that device, 40 tubes would result in 48 Wh/ tube.
The nominal value calculation may be helpful for theoretical calculation with a maximum number of tubes. When using commonly applied tube numbers in the lab like 10 or 12 tubes per run (especially when using 50 mL conical tubes), the theoretical consumption would be extremely high (like 195 Wh/ tube).
Using the nominal value of the power supply unit and dividing it by the number of tubes in the used rotor is a quick but very theoretical approach. This does not represent the reality in the lab.
Thus, it is clearly recommended to measure real consumption values of the centrifuge.

	Number of Tubes	Power Supply Unit (W)	Nominal Power Consumption/ Tube (Wh)
Centrifuge 5810 R	10	1.650	165
	28	1.650	59
Competitor	10	1.950	195
	28	1.950	69
	40	1.950	45

Table 5: Nominal power consumption per tube of Eppendorf Centrifuge 5810 R in comparison to one competitor

Measured power consumption - The reality

One can conclude that only real on-line measurements of power consumptions provide a reliable insight into the power consumption of a device.

	Number of Tubes	Nominal Power Consumption/ Tube (Wh)	Measured Power Consumption/ Tube (Wh)
Centrifuge 5810 R	28	59	29.7
Competitor	28	69	36

Table 6: Nominal power consumption per tube of Eppendorf Centrifuge 5810 R in comparison to one competitor

We processed, for example, test runs in pre-cooled devices of the Centrifuge 5810 R and an A-4-81 rotor with 28x conical tubes (each one filled with 50 mL of water). By using high speed (3,500 rpm) and cooling power at full throttle (4 °C), a run of 60 min resulted in a measured energy consumption (of the given devices) of 832 Watt for 28 tubes (832 Wh in total, 29.7 Wh/ tube).
When applying comparable conditions to a corresponding competitor device, the centrifugation of the same 28 tubes resulted in a consumption of 1,000 Watt (36 Wh/ tube).

For visualization, we compared the nominal and the real consumption by using the Centrifuge 5810 R.

Table 6 clearly shows the difference between nominal power consumption and real values measured under “lab conditions”.
When real power consumption is measured, the Centrifuge 5810 R (given devices) has a much lower power consumption than calculated by the nominal power consumption. This documents the high efficiency of the Centrifuge 5810 R.

The end is not the end - Recycling

For optimal support of the recycling process, instructions for disassembling describe the process of correct disassembling.
There is a high recycling quote for most of the parts within the centrifuge possible, especially when focusing on metal parts.
Besides the centrifuge itself, the Eppendorf rotors can be recycled as they are made of high-value aluminium.

Conclusion

In addition to silence, speed, and simplicity, Eppendorf's new generation of centrifuges offer different options for energy-savings (e.g., dynamic compressor control (DCC), improved standby consumption, ECO shut-off) to save up to 70 % of power per item. According to these energy-savings, this results in reduced electricity bills.

Keep in mind, it is not only the purchasing price of a device that matters but also the costs for electricity over the years of service.
Reward yourself with a good eco-emotion by using centrifuges with low power consumption and energy-saving features without compromises in temperature accuracy or sample safety.

For more information visit www.eppendorf.com/epGreen

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Your local distributor: www.eppendorf.com/worldwide
Eppendorf AG · 22331 Hamburg · Germany · Tel: +49 40 53801-0 · Fax: +49 40 538 01-556 · E-mail: eppendorf@eppendorf.com
Eppendorf North America, Inc. · 102 Motor Parkway · Hauppauge, N.Y. 11788-5178 · USA
Tel: +1 516 334 7500 · Toll free phone: +1 800-645-3050 · Fax: +1 516 334 7506 · E-mail: info@eppendorf.com

Application Support Europe: Tel: +49 1803 666 789
(Preis je nach Tarif im Ausland; 9 ct/min aus dem dt. Festnetz; Mobilfunkhöchstpreis 42 ct/min) support@eppendorf.com
North America: Tel: +1 800 645 3050 · E-mail: techserv@eppendorf.com
Asia Pacific: Tel: +60 3 8023 6869 · E-mail: support_asiapacific@eppendorf.com