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How Sustainable is My Pipette?

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Sustainability has a growing importance in the scientific community. Besides the well-known bags with biological, chemical, or radioactive waste, there is also the question about laboratory equipment and sustainability-related footprints. Liquid handling tools like pipettes may have – due to their small size – a low position on the list of concerns. The sustainability-related footprint of a product like this is a multi-factor story, including aspects related to development, production, logistics, usage in the laboratory, maintenance, and finally disposal. The focus of this White Paper is on the usage of pipettes in the laboratory and related sustainability aspects.

The importance and impact of sustainability on our lives increases every day. Wherever we interact in our personal lives, the topic of sustainability appears more and more often. The same holds true for the life in laboratories worldwide. Compared to just a few years ago, purchase decision drivers for lab equipment are no longer limited to i.a., performance, brand loyalty and price. The topics of sustainability, including the overall environmental and social impacts of a product life cycle, play an increasing role in the decision making process. Scientists, technicians, students, sustainability officers, and also purchasing departments and procurement systems request information. At Eppendorf, we see a growing interest in our company's commitments and approach to sustainability for all our products. This interest is split into different subtopics:

> Which raw materials are used in production?
> What kind of product design was developed?
> What steps is Eppendorf taking in their production facility/ as a supplier to improve the sustainability of its liquid handling tools?
> How are the products distributed?
> What can I do as a user in the lab to improve the sustainability footprint of my pipetting workflows?
> How much waste is generated in production and what is the end-of-life scenario? Are there zero waste concepts?
> How much of the product can be recycled?

Progress and continuous improvements with respect to sustainability require open communication about product performance and measures taken. In parallel, there are official third-party certification processes like the ISO 9001, ISO 13485, ISO 45001, and ISO 14001 for the Eppendorf Group, as well as external product labels like ACT® by NGO My Green Lab®.

In this White Paper, we focus on the first subtopic: What has been improved at Eppendorf, what is in progress, and where do we still see open tasks. Though a detailed life cycle analysis, also based on Scope 3 emissions (Scope 3 emissions describe greenhouse gas emissions along a company's value chain), is still challenging, there are certain elements that can be examined in the lifecycle of a pipette, especially before the unit is shipped to the laboratory. These aspects include the sourcing of and type of material, the location of and conditions in production, improvements taken in the development of new pipette generations, waste, power consumption, etc. When it comes to energy consumption in the laboratory, electronic pipettes are probably at the bottom of the list. Most suppliers do not publish the power consumption values of their electronic pipettes due to the very low consumption.

The challenge

Pipettes must fulfil a multipurpose function: From the user-perspective, they should be lightweight but extremely stable and robust, autoclavable, resistant to a wide variety of chemicals and cleaning agents but extremely precise and accurate over many years of use. These conditions require very specific materials and designs which makes simple improvements in terms of sustainability difficult. In particular, the use of recycled materials and the recycling of used pipettes is challenging and there are no viable solutions in the market so far.

Raw materials: Sourcing and material types

Although the design of a pipette is relatively simple compared to lab automation systems or complex analytical instrumentation, a lot of different parts are needed. In our global world, we are accustomed to acquiring parts and products from all over the globe, directly or indirectly via the delivery chain. For Eppendorf, all our direct suppliers need to act in accordance to our Code of Conduct. Our pipette manufactory, located in Hamburg/ Germany, receives a relevant share of all parts from local suppliers in Germany, as well as from Western Europe, within a 800 km/ 500 miles radius.

Major parts of the pipette are made of polymers, such as Polypropylene (PP), Polyetherimide (PEI), and Polyvinylidene fluoride (PVDF). The central axis is made of stainless steel.

Based on data by the European Recycling Industries' Confederation (EuRIC) (https:// www.euric-aisbl.eu/), the recycled content of European metal production is (on average) 55% for steel in 2020. Recycling of steel saves between 60-95% of the energy needed for primary production and is related to significantly reduced CO_2 emissions.

Figure 1: Serial production of Eppendorf Research® plus pipette

Raw materials: Packaging

The packaging concept of a product must maintain the product in a proper shape and condition. Development and intensive testing of the packaging is mandatory for a safe transportation of the product. For all liquid handling tools, the focus is on cardboard with high recycling content as main material. The cardboard-based tool-holding set-ups avoid the need for fixation foam. The plastic dustcover bag protects the instrument from dust and humidity. Depending on the type of pipette, there are different packaging systems:

Product	Recycling material in [%] of total packaging weight	Cardboard has recycling content of ca. [%]
Eppendorf Research® plus	76%	77%
Eppendorf Xplorer®	88%	92%
Multipette®* E3/ E3x	87%	92%
Multipette®* M4	69%	77%

*Known as "Repeater®" in the US market

Table 1: Recycling material content as percentage of total packaging weight and recycling ratio of cardboard packaging material of different Eppendorf liquid handling tools

With every new generation of a pipetting tool, we optimize the size of the packaging box to reduce the shipped box volume. The number of enclosed documents is reduced stepwise as a growing number of documents is available online at www.eppendorf.com.

Product design: Eppendorf testing procedure

The technical performance of a new pipette is optimized during the R&D process, and the data must be validated. Ongoing in-house checks are standard during the development of a new Eppendorf pipette. Numerous tests are conducted under controlled conditions in the R&D departments to understand and optimize the performance of our pipette prototypes. High-quality materials and rigorous stress tests ensure a durable build around the intricate inner workings designed for optimal accuracy and precision. Longevity of a product is a further building block for a more sustainable product or material footprint.

Product design: Longevity

The product lifetime of pipettes is often debated, as proving longevity can be challenging. A pipette might remain boxed for 9.5 years and only be used in the last six months, appearing new in its tenth year. Conversely, a workhorse pipette used continuously for 10 years may show signs of wear. During R&D, pipettes undergo extensive long-term load tests. High-quality pipettes, paired with proper maintenance and service, can easily function for 10 years or more. Calibration service data indicates regular servicing for pipettes up to 11 years old, with a notable drop-off for those 12 years and older.

Product design: Independent certification

Sustainability efforts can rather easily be claimed by many suppliers, but Eppendorf also seeks independent third-party validation for many of our liquid handling tools. We collaborate with the ACT® concept from My Green Lab®. Eppendorf partnered with My Green Lab the first time in 2018. The CryoCube® F740hi ULT freezer (Ultra-Low Temperature freezers) was the first ACT-labeled ULT freezer worldwide and one of the first laboratory products with an ACT label. In 2021, the Eppendorf Research® plus mechanical single-channel pipettes were the first pipettes worldwide to receive an ACT label. Since then, our electronic pipettes, Eppendorf Xplorer®, and multi-dispensers, Multipette®* M4 and E3, along with several pipette tip variants and other Eppendorf products have also been awarded ACT labels by My Green Lab, see also Figure 2. Details and certificates are available on our product pages: www.eppendorf.link/pipettes

My Green Labs mission is to constantly and permanently improve the sustainability within research labs. As a non-profit organization, My Green Lab focuses on joining and leading a broad community in the laboratory towards a world in which all research projects reflect the highest standards of social and environmental responsibility.

The organization, founded in 2013, has grown rapidly from a local non-profit organization to an international agent for change and improvement in respect to sustainability in laboratories worldwide.
Self-described as "Run for scientists, by scientists", My Green Lab develops standards for greener labs and lab products. These improved or new standards also need to be over-seen in respect to their implementation. One of the major challenges is the inspiration of the many behavioral changes that are needed throughout the scientific community.
This lab community encompasses a broad range of people in various roles, including scientists, vendors, designers, energy providers, and others. In 2024, Eppendorf also supported My Green Lab in developing the new ACT 2.0 standard

* Known as Repeater® in the US market

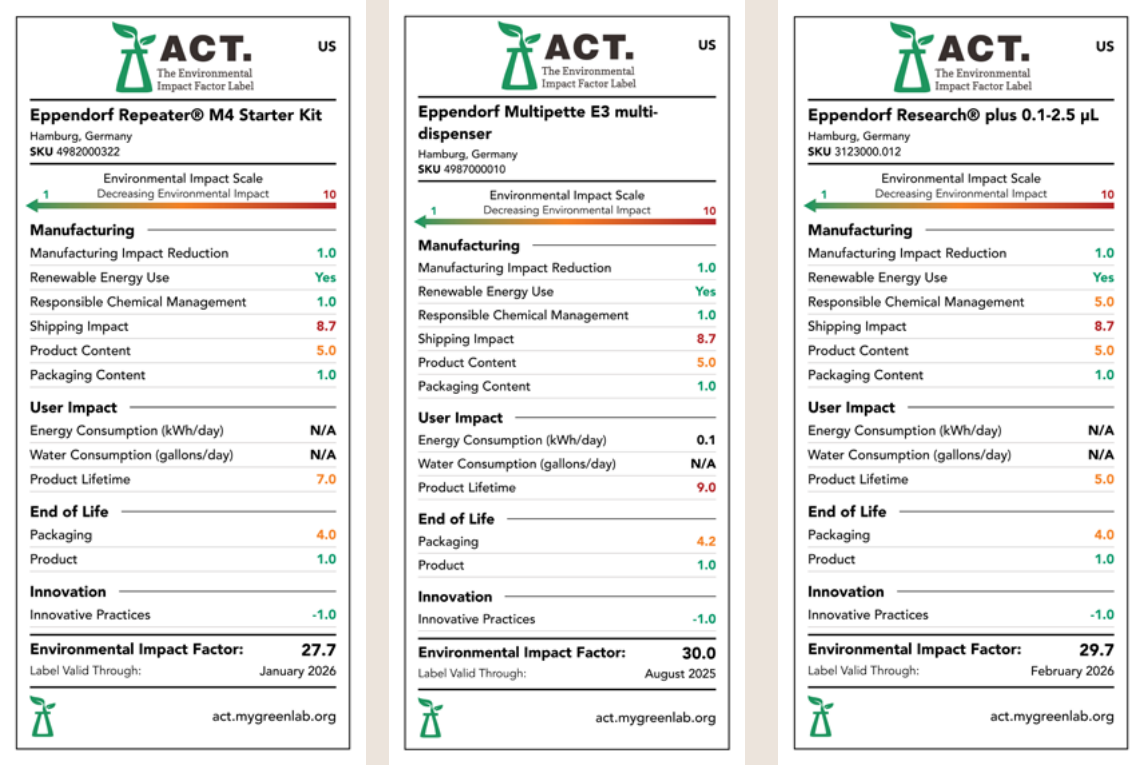

Figure 2: ACT® labels of different Eppendorf liquid handling tools

Production: Working conditions

Working conditions in the production facility are an essential part of the greater sustainability product picture. Our liquid handling tools are developed and assembled based on high EU regulations regarding social and environmental standards. Safety in production is supported by strict guidelines and regular safety trainings of all employees. Where required, personal safety equipment is worn. All critical components are documented and related material safety data sheets are available.

Figure 3: Production of Eppendorf pipettes with final volume check

Production: Generational improvements
Sustainability is based on a constant improvement of goods and products, accompanied and supported by innovative ideas. The same is true for product development in industrial settings. By combining the longevity and quality of our existing pipettes with future-proven new concepts, we are able to improve not only the performance but also the sustainability-related footprint of our next-generation pipettes.

Production: Waste in the facility
The term "waste" is challenging as non-used material or discard during production is quite often dismissed as "waste" although the material should be kept in the material cycle and being collected and re-used somewhere else.
The first goal regarding waste is to reduce the occurrence of the same. This requires constant optimization of the production processes. The molding of plastic parts is optimized to reduce the amount of molding discards. To reduce the amount of packaging material for delivered parts from suppliers, Eppendorf benefits from a growing number of returnable packaging boxes for parts. These boxes are shuttled back and forth between the supplier facility and the Eppendorf plant.

In the facility, there are special collection containers for cardboard, metal, and plastic. This sorting of single-use packaging materials from deliveries by suppliers significantly reduces the amount of final general waste at the facility.
Located in Hamburg, Germany, the Eppendorf pipette and dispenser production facility generates no classic landfill waste.
EU law mandates that standard waste must be recycled or incinerated (waste-to-energy). Landfill use is restricted to demolition waste and hazardous substances.
The Eppendorf sustainability report 2022 provides the different types of waste for all Eppendorf locations. The related percentages indicate the end of the different materials (see Table 1). The listed 62 t of landfill waste are related to renovations, rebuilding and building of several buildings.

[t]	Description	Percentage
2685	Total weight	100%
57	other recovery	66%
451	reuse	
1267	recycling	
818	incineration + energy	30%
7	incineration w/o energy	0.2%
23	other	0.8%
62	landfill	2%

Table 2: List of different waste streams of Eppendorf, based on 2022 sustainability report

Production: Renewable electricity
Eppendorf production facilities and office spaces are powered by renewable energy sources that comply with statutory environmental standards, enabling most facilities to achieve zero emissions in Scope 2 for electricity consumption. Since 2020, the assembly of our liquid handling tools in Germany has relied on power contracts with 100% renewable energy. Additionally, our pipette tips are molded at another Eppendorf factory using power contracts with 100% renewable energy. By sourcing electricity from renewable sources, Eppendorf has significantly reduced its CO_2 footprint across production facilities, achieving a 58% reduction from 2019 to 2022.

Production: Heating systems
The factory is supplied with heat from natural gas. The broad range of different production machines generates waste heat which is directly used to support warming up the buildings and reducing the amount of fossil gas used for heating.

With no quick solution to reduce emissions from natural gas heating systems in Central Europe, Eppendorf has decided to implement a compensation program for natural gas in 2024. Due to the critical evaluation of emission compensation programs, we try to reduce and replace wherever possible before taking the last option of compensation.

Distribution: Logistics
Eppendorf pipettes are primarily shipped via container ships from our central hub in Germany to global distribution centers in America and Asia. Within Europe, distribution is mainly done by truck. By utilizing several global distribution centers, we reduce global drop-shipments to a minimum. Our supply teams optimize container contents to maximize efficiency of space. Unlike heavier instruments such as ULT freezers or shakers, pipettes may sometimes be shipped with planes due to their low weight and volume. However, Eppendorf aims to minimize air transportation due to high emissions and costs. Local transportation relies on trucks and vans, with many logistic companies beginning to use electric carriers for light goods, although heavy e-trucks are still in early adoption stages.

Usage: Ergonomics

Ergonomics is part of the sustainability concept (well-being of yourself) and it is far beyond the »ergonomically designed chair«.
Eppendorf started to optimize their laboratory equipment regarding ergonomics already in the early 1970s. In 2003, we started the Eppendorf PhysioCare Concept®, incorporating ergonomics as key aspect of our pipette product design. Today, the PhysioCare Concept has expanded to encompass additional laboratory products, offering a holistic solution to harmonize workflow with health and well-being in your lab, exemplified by Eppendorf pipettes.

> Organic, lightweight, balanced designs and low pipetting forces help to reduce the risk of repetitive strain injury (RSI) still common among lab scientists
> Spring-loaded tip cones in Eppendorf pipettes reduce tip attachment and ejection forces. Staggered ejection in multi-channel pipettes reduces strain during tip ejection.
> With motor-operated pipette pistons, electronic pipettes offer even better ergonomics and comfort for your thumb, wrist, and arm.

Figure 4: Due to the long working times with pipettes, ergonomic design is crucial for safe handling without the risk of RSI

Usage: Longevity

The longer the life of an instrument, the more favorable for you as the user and for the environment. Price often plays a decisive role when purchasing a new piece of equipment, but it is important to keep in mind the expected lifespan of the instrument and the potential total cost of ownership over the years.
Longevity of a pipette is very important for the sustainability backpack. The longer a (well-maintained) instrument runs in the laboratory, the less resources you need to use per year, the less CO_2e is listed on your scorecard. A long lifetime is supported by regular calibration and maintenance done by qualified service technicians.

Figure 5: Maintenance of pipettes can extend the lifetime of the instrument

Usage: Calibration & maintenance services

Regular maintenance and calibration are important for ensuring the long-term precision and accuracy of pipettes and are ultimately supporting sustainability goals by extending the service life of pipettes and therefore reducing waste. The ISO 8655 standard mandates annual calibration and testing for piston-operated volumetric apparatus, including pipettes, defining criteria and permissible error limits to ensure reliable performance.
Eppendorf calibration services meet our highest standards, with ISO 17025 accreditation, ensuring traceability, measurement accuracy, and environmental controls. Servicing pipettes regularly helps prevent premature wear, maintains optimal functionality, and optimal precision and accuracy over many years of use.

Figure 6: Gravimetric check of an Eppendorf multi-channel pipette with a multi-channel balance

Figure 7: Decontamination of pipette by Ethanol-spraying before disposal

Usage: Spare parts
We aim to support the Eppendorf pipettes with spare parts for at least seven years after purchase, even beyond future pro-duction and sales stops. Their technical design allows for the replacement of many critical parts, with minimal use of glue and primarily secured by screws or clamps. Spare parts not only include components prone to typical wear, such as O-rings, but also pipette pistons, springs, lower parts, and ejector sleeves. This approach increases the chance to extend the typically very long service life of Eppendorf pipettes and dispensers even further through repairs.

Collection: Decontamination
Pipettes and dispensers are typically used in laboratories to handle biological samples. Please keep in mind to adequately decontaminate the liquid handling tools which need to be disposed and recycled. Check local requirements. For more information, get in contact with your local biosafety officer and/or waste officer. Check if your local recycling partner has special instructions and/or documentation requirements. You may also use the Eppendorf decontamination form sheet as guidance.

Recycling: Packaging end of life
The packaging "end of life" for liquid handling tools is usually reached after the shipment. Collection and recycling of all parts of the packaging is recommended. The packaging of the pipettes contains different materials, this includes cardboard and for some models a plastic dust cover. Recycling of materials becomes more and more important every day.

All packaging material can easily be split into the different material groups for recycling as there are no glued packaging materials. Please be aware about decontamination before transferring the packaging material into normal paper recycling bins. We recommend to unpack the liquid handling tools outside the contaminated areas in the laboratory, as you can then recycle all packaging material without any risk of contamination.
Are you aware that nearly all cardboard material is recycled in Europe? Please support the global sustainability initiative of recycling valuable raw material by also collecting the pipette cardboard packaging material and disposing of it in the appropriate collection container at your organization.
In respect to the plastic dust covers made of low-density polyethylene (LD-PE), we recommend to select a dedicated recycling partner where PE material can be recycled. We suggest you contact your local waste hauler and/ or facility management team to understand the available recycling options for your organization.

Recycling: Instrument end of life
Our pipettes last for many years, but if they need to be replaced, we kindly ask you to fulfill local requirements for disposal of these instruments. We strongly recommend a certified local recycling partner with experience in instruments with electronics when addressing electronic pipettes. Keeping it "local" reduces the impact of transportation, and the "certified" aspect is recommended due to the safe and sustainable removal of specific parts.

Summary

Sustainability in the laboratory is attracting more and more attention, with growing demand for data on equipment. Eppendorf has decided to follow and to support this pathway. The ACT certification process requires an in-depth review of a company's sustainability programs and an examination of all the environmental factors related to a selected product. By certifying our liquid handling tools, Eppendorf is more dedicated than ever to supporting the planet and its people through Accountability, Consistency, and Transparency in reducing environmental impact.

But there is more to do. Eppendorf understands that „going green" must be grounded in facts. Creating more sustainable products requires continuous development of new features and technologies to reduce raw material usage, energy consumption, and the environmental impact of our business and products. These challenges cannot be solved quickly or easily, but require a collective approach and consistent effort to collaborate and listen to one another. Supporting organizations like My Green Lab is an important building block of this journey. A focus on the environment ultimately provides a more sustainable future for everyone.

About Eppendorf

Since 1945, the Eppendorf brand has been synonymous with customer-oriented processes and innovative products, such as laboratory devices and consumables for liquid handling, cell handling and sample handling. Today, Eppendorf and its approximately 5,000 employees serve as experts and advisors, using their unique knowledge and experience to support laboratories and research institutions around the world. The foundation of the company's expertise is its focus on its customers. Eppendorf's exchange of ideas with its customers results in comprehensive solutions that in turn become industry standards. Eppendorf will continue on this path in the future, true to the standard set by the company's founders: that of sustainably improving people's living conditions.

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