Premium Laboratory Equipment

Magnetic stirrers with heating function:

Alternatives & temperature control accessories

Buyer's Guide

heidolph
research made easy

Why this Buyer's Guide?

Heat accelerates the speed of chemical reactions and solution processes. Today, due to safety reasons, only electrically heated devices are used, whereas in former times, the reaction media were warmed up and heated over an open flame. This is why a wide selection of different laboratory instruments permitting a precise temperature control, has to be part of the essential basic equipment.

This Buyer's Guide gives you an overview of the operating principle and the temperature behavior of the devices as well as the advantages that the heating options entail in terms of safety, costs, hygiene, sustainability, speed, space savings and flexibility.

Contents

① The operating principle of patio heaters

Heating hoods, also called patio heaters or heating mantles, are semicircular electrical radiators for round bottom flasks. The heating mantle with integrated heat conductors is worked with glass silk, mainly by hand. Depending on the flask size, heating hoods dispose of 1 or 2 heating zones. For use with an external magnetic stirrer, specific heating hoods with a bottom hole are available.

The flexible material of the heating mantle has the advantage that the heat can be evenly distributed in the reaction liquid. The heating rate of worked heating hoods is remarkable, however it cannot keep up with a powerful magnetic stirrer with heating function. An internal comparative measurement of a heating hood and a Heidolph Hei-Tec magnetic stirrer model has shown that the tested heating hood needs 31 minutes to heat 800 ml of water in a 1-l-round bottom flask to 100 °C, whereas the magnetic stirrer with heating function only needed 17 minutes.

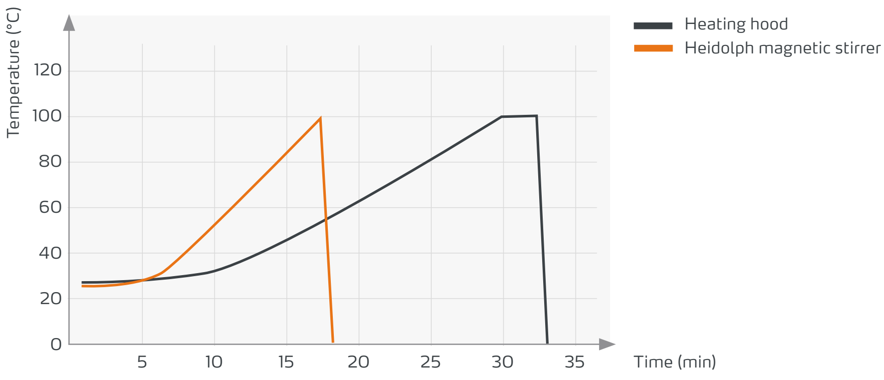


Fig. 1: Independent comparative measurement of the heating rate [1]

But be careful!

Heating hoods should only be used in combination with an additional temperature control for chemical reactions. Without the possibility to set the heating temperature and to regulate it, the heating elements continue to heat and heat up substances far beyond their boiling point. This is why experiments are not reproducible and in the worst case, compounds are destroyed and the experimental results are unusable.

In case of a glass breakage, it should be excluded that liquid comes into contact with heat conductors and that a short-circuit or even a fire is triggered. During the purchase, make sure to pay attention to safety features such as protective earthing of the heat conductors, residual-current devices and insulation of the heat conductors against liquids.

② The operating principle of a magnetic stirrer with heating function

The stirring and heating of low-viscosity solutions as well as of liquids with a low solid content using magnetic stirrers with heating plate is part of everyday life in each chemical laboratory. Here, the stirring forces are not transmitted via a stirrer shaft but via magnets. Under the plate of the device, there is a permanent magnet which is set in rotation by a small speed-controlled electronic motor which thus generates a rotating magnetic field. In the reaction vessel above, there is the magnetic mating part, the stirring bar which is kept on the bottom of the vessel via the magnetic forces and which is set into a rotating motion at the same time. The solution gradually mixes in the resulting water vortex. Initially patented in 1944, magnetic stirrers brought significant benefits to the laboratory. They allow the mixing of solutions in closed vessels and without an open flame – and thus without the risk of explosion when using flammable solvents. (CAUTION: When heating up closed vessels, pressure is caused in the vessel! There is a risk of bursting.) The magnetic power transmission is realized in a frictionless and wear-free way. Thus, magnetic stirrers are suitable to the continuous operation, even during high speeds.

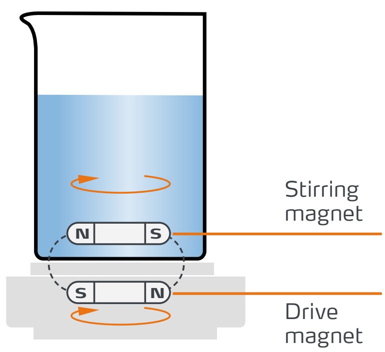


Fig. 2: Setup of a magnetic stirrer

[1] *Source: internal comparative measurement of the Hei-TEC, Heidolph Instruments*

③ Temperature control accessories for magnetic stirrers with heating function

In almost 70% of the cases, magnetic stirrer users need a device with heating function for their applications in the laboratory.[2] Synthesis, extraction, distillation, sublimation, crystallization and reflux reactions are among the most common ones. For about 80% of these applications, accessories are used to control securely, precisely and properly the temperature of the solution in the reaction vessel.

Generally, each each temperature control accessory is placed on the heating plate of the magnetic stirrer, absorbs the heating energy and transmits it to the solution in the reaction vessel. With one exception: When controlling the temperature of the solutions, beakers or Erlenmeyer flasks are located directly on the heating plate.

3.1.1 Direct heat input

Typical application: Production of solutions (salts and other soluble solids) or agar-agar solutions while stirring and heating in the open beaker or Erlenmeyer flask.

The reaction vessels – Erlenmeyer flask or flat-bottomed beaker – are placed on the heating plate. The heat input is effected directly on the glass and thus into the solution.

It is also possible to heat, boil and evaporate in the different glass apparatus. However, this method reaches its limits for most of the laboratory applications due to the uneven temperature distribution and the poorer controllability in comparison to the indirect heating.

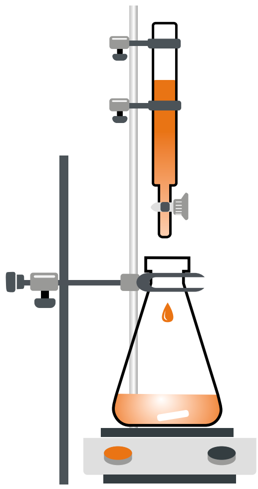


Fig. 3: Schematic illustration of an application with Erlenmeyer flask

3.1.2 Indirect heat input via the heating bath

Typical applications: Heating under reflux, refluxing and dropping, extracting, reactions with water separator, distillation etc.

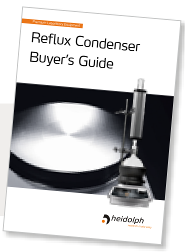
Liquid baths are the most common method in the laboratory to transmit heat indirectly to a reaction vessel. A high thermal conductivity, an excellent controllability and a good temperature distribution are the reasons for the use of liquid heat transfer media. Due to the poor temperature controllability and toxicity, other intermediate media like sand or molten metals are only used for special applications and if extremely high temperatures are required.

Water has a high heat capacity but is only suitable as heat transfer medium for temperatures until approx. 70 °C due to the low boiling point. Otherwise, the evaporation rate would be too high. If higher temperatures until approx. 250 °C are necessary for the reaction, then water-soluble polyethylene glycol and silicone oil shall be used for open heating baths. The most important advantages are the low evaporation rate and toxicity, the high heat resistance in the air as well as a low chemical reactivity.

But be careful!

The most important disadvantages are the slow heating, the high risk of burns, of injury and of property, the high operating costs (as oil has to be changed regularly) as well as a costly disposal. The oily bath liquid often drips down from the round bottom flask and contaminates the laboratory environment. Furthermore, it settles on the reaction vessel which has to be thoroughly cleaned after use so that future experiments are not falsified. If water drips down from the cooling liquid tubes above the oil bath, an explosive evaporation can be the consequence. Moreover, when the humidity is high, water bubbles can accumulate in the silicone oil so that it is necessary to boil it before the next use. And last but not least, a burning oil bath cannot be extinguished with water or CO_2, the flames have to be extinguished with a special cover.

Reflux Condenser Buyer's Guide – Alternative with air instead of water



[2] *Source: internal customer survey, Heidolph Instruments*

A. A. The crystallization cup as bath vessel

Fig. 4: Crystallization cup

Crystallization cups, like all reaction vessels, are made of water-resistant, chemical-resistant and temperature-resistant inert borosilicate glass.

As they are relatively cost-effective and are part of the essential basic equipment in practically each laboratory, they are often "misused" for oil baths and heated on the plate of the magnetic stirrer.

But be careful!

The high temperatures of the bath liquids carry the risk of serious burns or injuries. If crystallization cups are used as oil bath containers, oil often reaches the outside as it expands considerably when being heated. Heating baths are usually placed on a lab jack to separate the reaction flask quickly from the heat source. When lowering the lab jack, the oil bath can slide down from the top plate of the magnetic stirrer and, in the worst case, can break.

As crystallization cups do not have handles, the bath liquid has to be cooled down before transport. Spilled bath liquid increases the risk of slipping and the residues have to be absorbed with tissue papers and solvent or an oil absorbent and have to be properly disposed afterwards.

B. The heating bath/bath pot

Abb. 5: Badaufsätze

The secure alternative to the crystallization cup No risk of slipping, no glass breakage and an easy transport thanks to the side handles.

Heidolph bath attachments are available from a capacity of 1 to 4 liters. They suit for all Hei-PLATE magnetic stirrers with heating function, fit perfectly on the top plate and can thus not slide down. In the standard version, they are made of the material aluminium, known for its high thermal conductivity. They are optionally available with a high-temperature-resistant and corrosion-resistant non-stick coating and are then universally suitable as heating and oil bath. They can be cleaned easily and are chemically resistant. However, due to the massive design, they have a higher purchase price than crystallization cups.

Valuation

Safety	★★☆☆☆
Installation, operation and maintenance	★★★★☆
Sustainability	★★☆☆☆
Acquisition cost	★★★★☆
Operating costs	★★☆☆☆

3.1.3 Indirect heat input via reaction blocks

Metal reaction blocks can replace the oil bath as heat transfer medium for almost every application. They have one or more semicircular, custom-fit recesses for a large number of vessels such as standard round-bottom flasks, multinecked flasks, vials and test tubes of different sizes. The reaction blocks are placed on the heating plate of the magnetic stirrer and transmit the heat to the reaction vessel.

Most of the commercially available reaction blocks are made of anodized aluminum. The light metal combines two important characteristics: It has an excellent thermal conductivity and is not ferromagnetic, thus it has no effect on the magnetic field of the magnetic stirrer.

A. The Heat-On™ attachment

Fig. 6: Heat-On™

The surfaces of the high-quality attachments are finished with a durable, highly chemical-resistant and scratch-resistant PTFE-coating. If several reaction vessels shall be heated at the same time, special Multi-Well holders and inserts are available.

Even more secure

In comparison with an oil bath, Heat-On™ attachments offer much more safety. The risk of serious burns is considerably reduced as hot oil cannot be spilled. The risks of an evaporation due to dripping water as well as of slipping due to spilled oil are completely eliminated. Thanks to the specially shaped deep wells, the risk of glass breakage equals zero, too. However, the residual risk of burns when touching accidentally the hot Heat-On™ attachments, remains. For the safe removal of the heating plate, we recommend the use of the optional safety lifting handles which can be inserted in two openings at the edge of the Heat-On™ attachment or of the Multi-Well holder. If injuries caused by touching the hot surfaces shall be excluded, you better use the additional appropriate safety covers made of PTFE. They reduce the surface heat by up to 50 %.

Cleaning easier

When using oil baths and while removing the test tubes, bath liquid drips down time and again and contaminates the laboratory environment. This does not happen using a dry Heat-On™ attachment. The residue-free cleaning of the glass vessels is also less critical. Due to the non-stick coating, the attachments and Multi-Well inserts can be kept clean easily.

Faster heating and process times

All Heat-On™ blocks are low in material and weight. Thus, they heat up very even, quick and without forming heat islands. The wells enclose every flask perfectly, even on the top and provide maximum surface contact. This ensures the lowest heating times and minimizes the temperature difference between the block and the reagent liquid. For measuring the temperature outside the medium, an external PT 1000 temperature sensor can be inserted in an opening of the Heat-On™ wall. Another advantage is the fast sample throughput due to the handling being much easier.

More sustainable and economical

The heating times – compared to conventional heating baths, they are reduced by more than 60% – are also reflected in the power consumption and thus in the energy costs. The safety covers can reduce the energy consumption during long-term operation still further by up to 15% as they function as a thermal insulation of the Heat-On™ reaction blocks. Not least, the renunciation of the expensive heating bath liquid makes the Heat-On™ attachments more economical, more sustainable and greener: No need to buy heating bath liquid again and to dispose it costly, no additional garbage by using cleaning tissues constantly. Only when considering the acquisition costs, Heat-On™ attachments are more expensive than bath pots.

Flask size (ml)	Volume (ml)	Heating plate temp. (°C)	Time until boiling point (min)
10	6	300	6.8
25	15	300	8.0
50	30	300	8.5
100	60	300	8.8
150	100	300	10.0
250	150	300	10.8
500	300	300	16.4
1,000	600	300	21.1
2,000	1,200	300	35.1
3,000	1,800	300	47.3
4,000	2,400	300	51.0
5,000	3,000	300	75.5

Heating power: Heating times of different amounts of water until the boiling point using Heat-On attachments of different sizes

Valuation		
	Safety	★★★★★
	Installation, operation and maintenance	★★★★☆
	Sustainability	★★★★★
	Acquisition cost	★★☆☆☆
	Operating costs	★★★★☆

B. The variable StarFish Workstation

Fig. 7: StarFish plate with different polyblocks

The compact and flexible StarFish system has been developed for the parallel and/or multiple carry out of common applications, such as heating, refluxing, extracting and in particular the Soxhlet extraction.

Compared to the Heat-On™ attachment, this modularly designed accessory for magnetic stirrers offers three other advantages for daily stirring tasks in the laboratory: the processes become even more efficient, the setup is space-saving and especially extremely variable. On Heidolph magnetic stirrers, up to 45 samples can be placed simultaneously in common reaction vessels from 10 ml to 250 ml. Recommended/maximum temperature for continuous use: up to 200 °C/260 °C.

Space-saving thanks to its compact design

The StarFish system creates order in the laboratory fume hood as all parts interlock. Whether it is about a complex setup with reflux condensers or about simple stirring tasks in small reaction vessels, the lateral space requirement is hardly wider than the aluminium baseplate lying on the magnetic stirrer and transferring heat to the reaction vessels.

Flexibility increases sample throughput

The system parts can be combined individually and depending on the requirements. MonoBlocks, as the name suggests, are one-part reaction blocks with 5 to maximum 40 recesses for uniformly sized reaction vessels. With PolyBlocks, up to 5 reaction block segments can be combined for different vessel sizes. Apparatus for Soxhlet extraction, distillation and stirring under reflux can be installed in a fast, secure and space-saving way with additional accessories such as the support rod, the 5-way telescopic clamp as well as the gas/vacuum or water manifold. The flexibility and the wide range of equipment mean higher acquisition costs compared to the Heat-On™ attachments.

Fig. 8: This 5-way clamp with telescopic arms reminds of a starfish

Valuation		
	Safety	★★★★★
	Installation, operation and maintenance	★★★★☆
	Sustainability	★★★★★
	Acquisition cost	★☆☆☆☆
	Operating costs	★★★★☆

④ Conclusion

The awareness of safety and health protection is omnipresent in the modern laboratory. Thus, this purchase criterion is not a can do, but a must. The topics of sustainability and energy efficiency become ever more a top priority.

This Buyer's Guide shows that, besides the obvious criteria for the purchase decision, a lot of essential questions need to be clarified. Are the laboratories very busy? Are there always problems with cleanliness? Is the place in the fume hood limited?

Do the teams spend more time with waiting and constructing apparatus than with the actual research and evaluation? Then, the well thought out Heidolph accessory parts for magnetic stirrers with heating function offer the possibility to reduce process times, to work more productive and to increase the sample throughput.

Any questions?
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Further links:
Heidolph Magnetic Stirrers
Heat-On Blocks
StarFish Workstation

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