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PHOTOSYNTHETIC PILOT REACTOR

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1. Introduction.

The MELISSA Pilot Plant, currently located at the Department of Chemical Engineering of the Universitat Autònoma de Barcelona, has been conceived to integrate the knowledge developed by the different groups involved in the project, and to demonstrate the feasibility of the concept and the robustness of its operation. At the present time, two bioreactors, corresponding to compartments III an IV of the MELISSA loop (as described in Figure 1), are in operation in the Pilot Plant. The bioreactor corresponding to compartment IV, where the cyanobacteria *Spirulina platensis* is grown using the light as energy source, is the most developed so far. As a step forward in the development of the Pilot Plant, the second phase of the work plan, includes the design and construction of a new bioreactor for compartment IV. Simultaneously, the bioreactor currently used for *Spirulina* will be modified to adapt it to the culture of *Rhodobacter* cells for compartment II (a proposal for these modifications is presented in TN 25.4). In this TN a basic proposal regarding the concept for the new bioreactor is made. In case of acceptance by ESTEC, this proposal will be discussed with the bioreactor manufacturer to establish all the specific details in order to proceed to its construction and set-up. Three main aspects constitute the driving force for the new bioreactor design :

- to scale-up the volume of the bioreactor to a volume enabling a oxygen production to sustain the life of three rats.

- to maintain as far as possible the current type of bioreactor, in order to use efficiently all the knowledge developed in the present unit (for example, the knowledge model between cell growth and light intensity).

- to improve the operation of the bioreactor proposing alternatives for some of the peripheral equipment/instrumentation. Some of these changes are due to the availability of new equipment, and others are directly linked to the change of size. The number of changes should be minimised to those with a clear impact in the reactor operation. According to these objectives, this TN has been divided in two parts : new bioreactor design and auxiliary equipment. A detailed description of the bioreactor currently employed has not been considered necessary, as can be easily obtained from

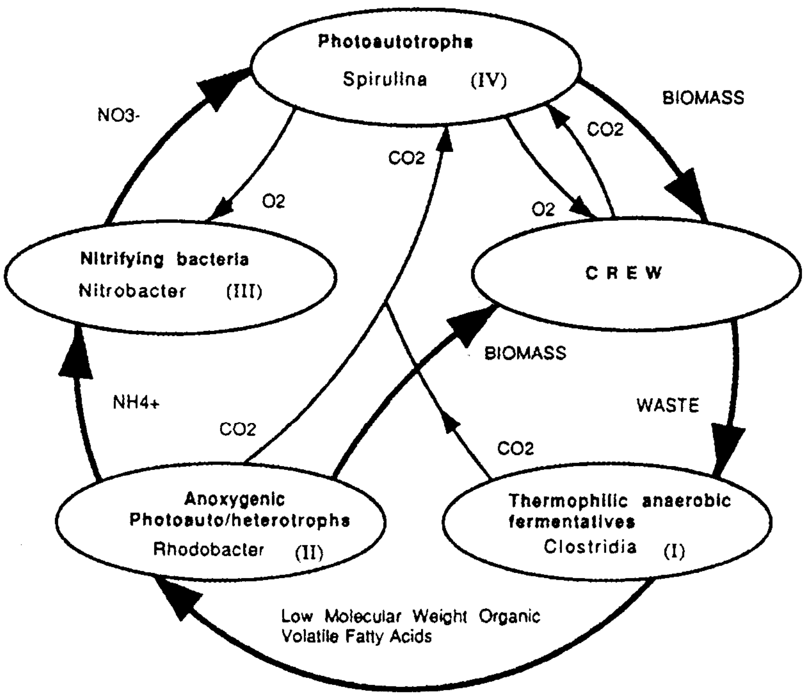


Figure 1. General concept of MELISSA and its compartments.

previous MELISSA documentation (Binois 1994).

2. The new bioreactor design.

2.1 Basic considerations

As mentioned in the introduction, two previous requirements for the design are to use the same concept of bioreactor, that is, an air-lift, and to scale-up the working volume to be able to sustain the life of three rats. In order to scale-up the current bioreactor to its new size several preliminary points were considered :

- the size increase could require an increase in the reactor diameter. This would reduce the ratio of surface to volume in the reactor, therefore making more difficult the illumination of the cells. Qualitatively, given a cell concentration, for the same intensity of the light at the external surface of the reactor (Fr), the light intensity in the centre of the bioreactor will be lower for a larger diameter. This will generate, especially when high concentrations of cells would be desired, a dark volume inside the bioreactor, in which the light intensity would be too low ($<1 W/m^2$) and where the cells would not grow. This drawback of a diameter increase could be compensated by increasing the Fr. However this has a physical limit (the level of Fr required for a large diameter may not be attainable), and, more important, too high Fr would cause inhibition to the cells growth. Thus, increasing Fr from 400 W/m^2 would possibly create a volume of the reactor where cell growth would be inhibited.

- the scale-up in the reactor volume can not be realised only by maintaining the diameter of the present bioreactor and increasing its height, because the height of the laboratory imposes obvious restrictions. In addition, the construction and the working conditions (for example pressure) would also be more adverse.

-in terms of reactor homogeneity regarding illumination, a desirable feature of the design is to have a high ratio between the volume of the illuminated zone with respect to the total reactor volume (Vil/Vt). This ratio is 0.52 for the reactor presently used.

- a meaningful magnitude to calculate in the design of the reactor is the volumetric rate of energy absorbed in the photobioreactor, <A>, which is related to the radiant energy available and therefore to cell growth rate. As described by Cornet et al (Cornet et al, 1993), the relationship between Fr and <A> for a cylindrical reactor is given by :

$$\frac{A}{2F_r/R} = \frac{2\cdot\alpha\cdot sinh\cdot\delta R}{\cosh\delta R + \alpha\cdot\sinh\delta R} \qquad (1)$$

As <A> depends of the way to illuminate the reactor and its geometry, it is a specific data of a bioreactor. However, when the mono-dimensional approximation is expected, equation (1) will remain valid as long as the cylindrical geometry is not changed. Therefore, this relationship can be used to study what increase in Fr is required to maintain the same values of <A> in reactors with different diameters.

Taking into account these different aspects, some alternatives for the bioreactor design have been studied, and their main features are summarised below. In order to do some of the calculations, basically those linking the incident radiant energy flux at the external surface of the bioreactor (Fr) and the radiant energy flux at the centre of the bioreactor (Eb) the corresponding sections of the PHOTOSIM program have been used.

The four configurations used to study the effects of the design on the different magnitudes of the reactor are :

- the air-lift reactor presently used (reactor 1, figure 2)

- an air-lift reactor with an increased diameter of 0.12 m (reactor 2, figure 3)

- an air-lift reactor with an increased diameter of 0.17 m (reactor 3, figure 4)

- an air-lift reactor with an external loop, with a diameter of 0.12 m (reactor 4, figure 5)

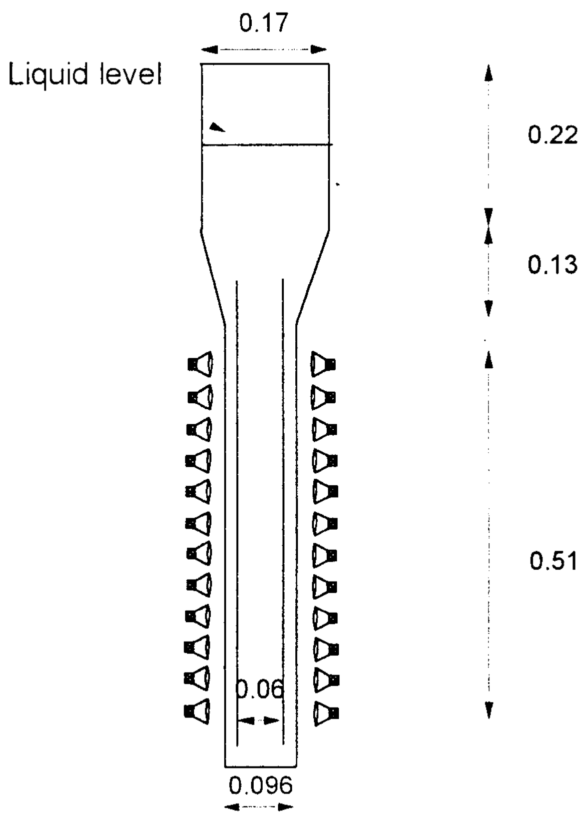


Figure 2. Current air-lift bioreactor configuration (reactor 1).

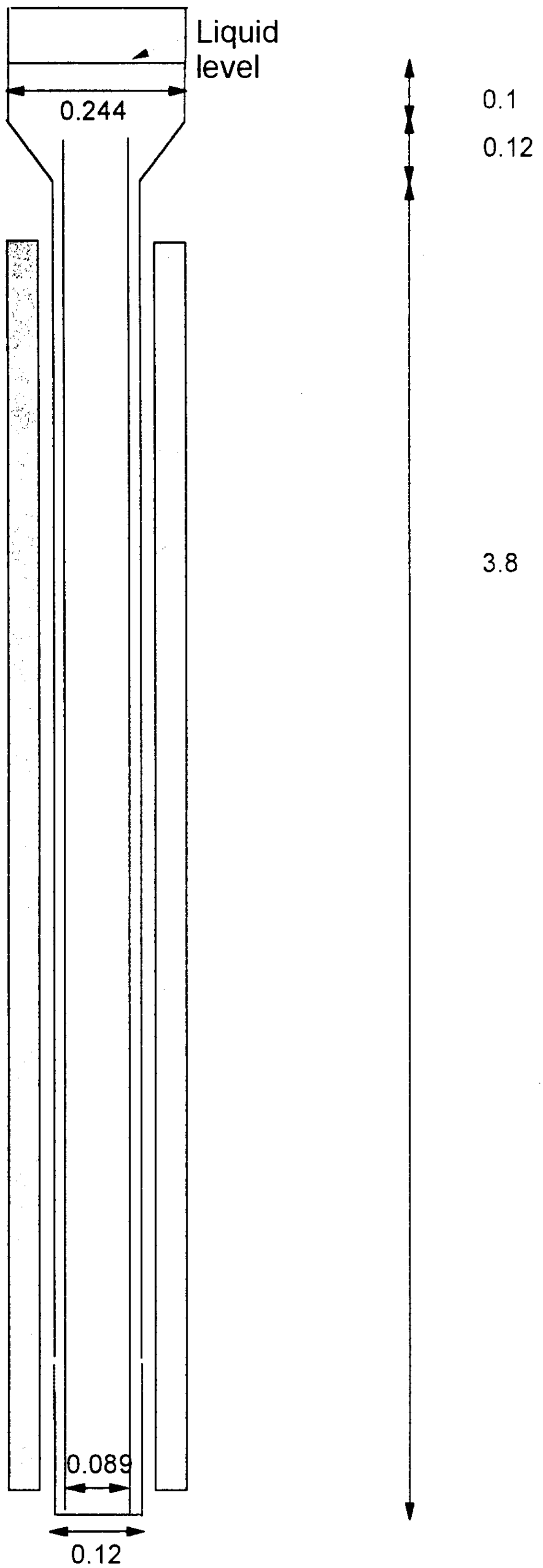


Figure 3. Air-lift dimensions for 0.12 m diameter (reactor 2).

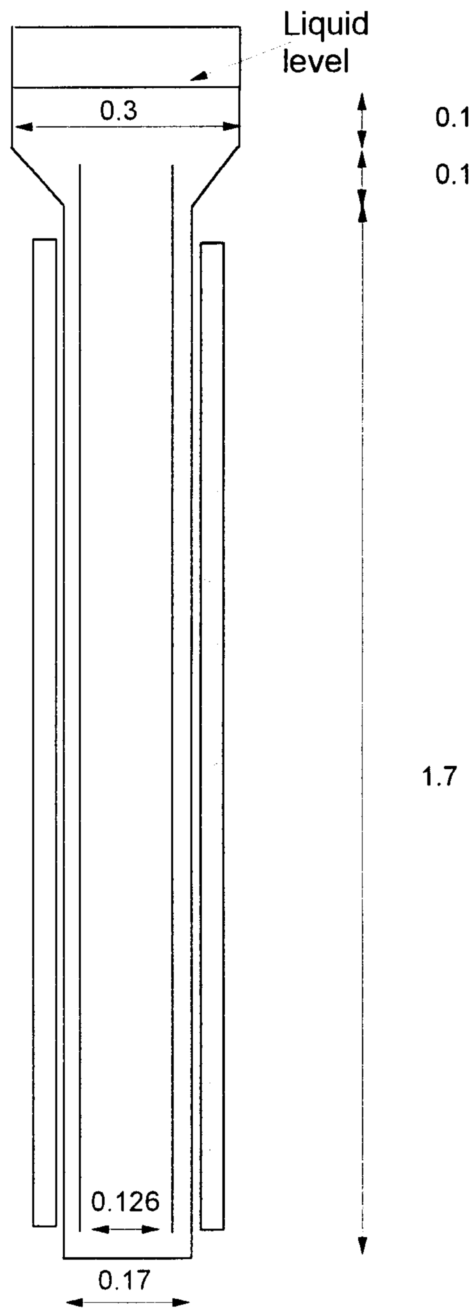


Figure 4. Air-lift dimensions for 0.17 m diameter (reactor 3).

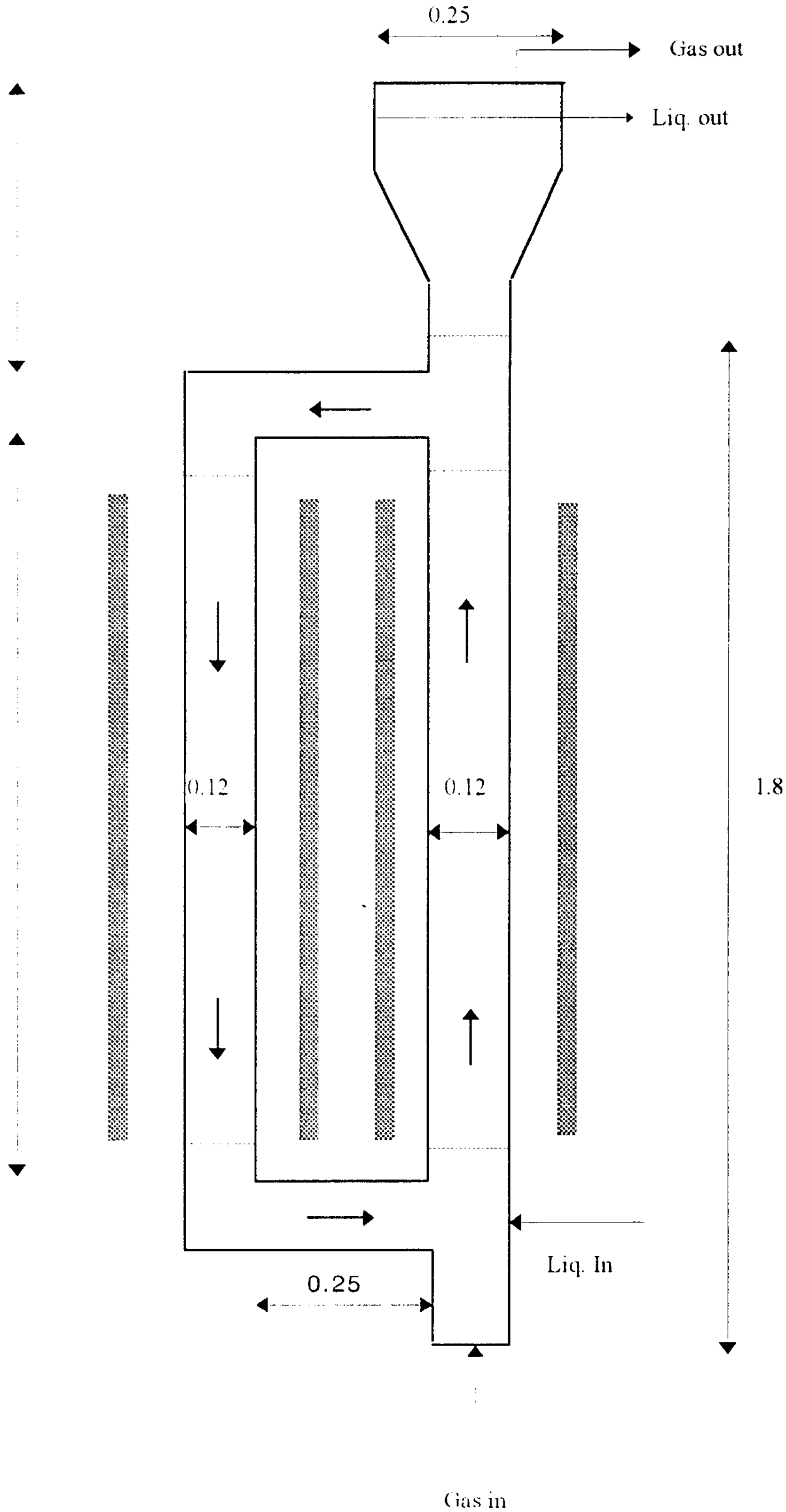


Figure 5. External loop air-lift configuration (reactor 4).

In all the bioreactors proposed, the different design relationships, such as the ratio between reactor and internal draft tube diameter, or the ratio between the reactor diameter and the gas separation section have been calculated according to the general criteria proposed in the literature of air-lift bioreactors (Chisti 1989, Chisti and Young 1993).

Table 1 gives the values of the different radius according to the scheme proposed in figure 6 and the mathematical model developed previously (Cornet et al. 1993), employed for each reactor in the simulations done with PHOTOSIM.

	reactor 1	reactors 2,4	reactor 3
R	0,048	0,06	0,085
r1	0,0302	0,0497	0,068
r2	0,02585	0,0447	0,063
r3	0,0115	0,0115	0,0115
rb	0,0095	0,0095	0,0095

Table 1. Values of the different radius corresponding to the reactors studied, according to Figure 6, as used in PHOTOSIM.

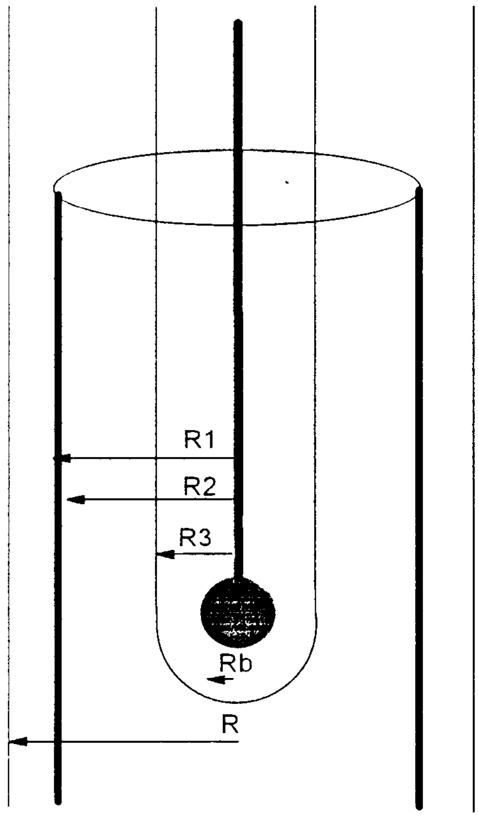


Figure 6. Definition of the different radius in the reactor.

Table 2 gives the values of some general magnitudes for each reactor. It can be observed that the ratio between the illuminated area to the total reactor volume is maintained at similar level for most of the designs, with a considerable increase for configuration 2. For that case, the ratio of the illuminated to total volume is also highest. However, this configuration is not possible, because the height is too high. This, in addition to the limitations of the pilot plant laboratory would add difficulties in the construction and operation of the reactor.

Regarding the illumination conditions, the results obtained with PHOTOSIM for the current bioreactor (diameter 9.6 cm) and the two diameters used as study case (12 and 17 cm) in this TN, using different criteria, are summarised in tables 3 to 6.

	reactor 1	reactor 2	reactor 3	reactor 4
Useful volume (dm^3)	7	49,97	49,96	54
Illuminated volume (dm^3)	3.68	42,95	38,56	37,3
Illuminated volume/total volume	0,52	0,85	0,77	0,69
Illuminated area/total volume (m^{-1})	21,54	28,64	18,16	22,9

Table 2. Values of some general magnitudes for the different reactors studied

In table 3, the Eb values at the centre of the current bioreactor are calculated for two different values for Fr (195 and 400 W/m^2) and Cx (0.7 and 1.4 g/l). This conditions are taken as a basis for the comparison of the simulation results of the different configurations. It should be noticed that in this case, for the higher cell concentration the corresponding Eb values are below the value limiting cell growth (1 W/m^2).

In table 4, the Eb values for the same situations studied in table 3 are given for the other two diameters, 12 and 17 cm. The drastic effect of the diameter on the light availability is evident, and these results corroborate quantitatively the limitation of the scale-up procedure regarding diameter increase. This fact can also be observed in the results presented in tables 5 and 6.

In table 5, the values of Fr necessary for the two new diameters in order to maintain the same <A> values than for the current configuration , and their corresponding Eb, are given. It can be noticed that in spite of the increase in Fr to values higher than 400 W/m^2, the Eb values are very low for the case of 17 cm diameter, and about 10% for 12 cm diameter, when compared to the data in Table 3.

Table 6 gives the results when the calculations are made using the criteria of obtaining the same Eb value for the 12 and 17 cm configurations, than in the current configuration, for the conditions in table 3. In accordance to the previous points it can be observed the high Fr values that should be required.

Fr	Cx	Eb	<A>
195	0,7	25,07	7768,9
195	1,4	0,356	7768,9
400	0,7	51,42	15807
400	1,4	0,73	15807

Table 3. Eb values for reactor 1 at different conditions.

<A>	Cx	Fr reactors 2,4	Fr reactor 3	Eb reactors 2,4	Eb reactor 3
7768,9	0,7	241,8	342,5	8,52	0,604
7768,9	1,4	241,8	342,5	0,026	6,64E-05
15807	0,7	495,94	702,6	17,478	1,239
15807	1,4	495,94	702,6	0,054	1,36E-04

Table 4. Eb and <A> values for the different configurations, for the same conditions used in table 3.

Fr	Cx	Eb reactor 1	<A> reactor 1	Eb reactors 2,4	<A> reactors 2,4	Eb reactor 3	<A> reactor 3
195	0,7	25,07	7768,9	6,872	6215	0,344	4387
195	1,4	0,356	7768,9	0,021	6215	3,78 E-5	4387
400	0,7	51,42	15807	14,097	12749	0,705	8999
400	1,4	0,73	15807	0,044	12749	7,759 E-5	8999

Table 5. Values of Fr and Eb for the different configurations, for the same <A> values than reactor 1.

Eb	Cx	Fr reactors 2,4	Fr reactor 3
25,07	0,7	711,3	1,42E+04
0,356	1,4	3,24E+03	1,83E+06
51,42	0,7	1,46E+03	2,92E+04
0,73	1,4	6,65E+03	3,76E+06

Table 6. Values of Fr for the different configurations, for the same Eb than reactor 1.

In conclusion, from the results of these calculations, and taking into account the rest of criteria already enumerated, the basic concept proposed for the new *Spirulina* bioreactor is as configuration 4. That is, an air-lift bioreactor with an external loop downcomer, and with a relatively moderate increase in diameter (new diameter around 12 cm) with respect to the current configuration. This design represents a compromise between volume required, physical size, illumination conditions, and relatively simple configuration.

Following this conclusion, a more detailed design of the bioreactor has been elaborated. For this the volume and illumination needed to fulfil the preliminary requirement of sustaining the life of three rats has been taken into account.

2.1 Bioreactor sizing and detailed design.

According to the previous results obtained with rats (de Chambure 1992, Tranquille 1992) it will be assumed that a rat (weighing between 200-400 g) can consume 25 g/day of *Spirulina*. This rats consume about 1 l O_2/Kg $\cdot$h and evolve 0.9 l CO_2/kg $\cdot$h. Therefore for an hypothetical experiment using 3 resting rats of about 400 g in weight, 3.125 g/h of *Spirulina* have to be produced. At the same time this *Spirulina* should produce at least 1.2 l O_2/h (5.36 10^{-2} mol O_2/h) and consume about 1.08 l CO_2/h. If the rats are in an active state a coefficient of 2.5 can be applied to correct for the increased oxygen consumption. This results in a consumption of a 3 l O_2/h (0.134 mol O_2/h) and an approximate production of 2.7 l CO_2/h. Those values have been taken as a starting point for the following calculations.

Using PHOTOSIM, which at this moment can appropriately represent the available experimental data, a bioreactor illuminated with an Fr of 300 W/m^2, can produce a biomass productivity of 6.9 10^{-2} g $\cdot l^{-1} \cdot h^{-1}$. while producing 3.33 10^{-3} mol $O_2 \cdot l^{-1} \cdot h^{-1}$. From the oxygen amount needed for the three active rats it can be calculated that a volume of a bioreactor (with the same characteristics as the one used in PHOTOSIM) of 40 l would be required. A similar calculation done for the biomass produced will give that a bioreactor of 44 l is required. If we take the 40 l bioreactor a 90% of the rats daily food intake can be fulfilled. This is judged satisfactorily at this moment as the food intake of the rats is expected to be supplemented, in the laboratory ,either by another compartment in the MELISSA loop or by an external supplement.

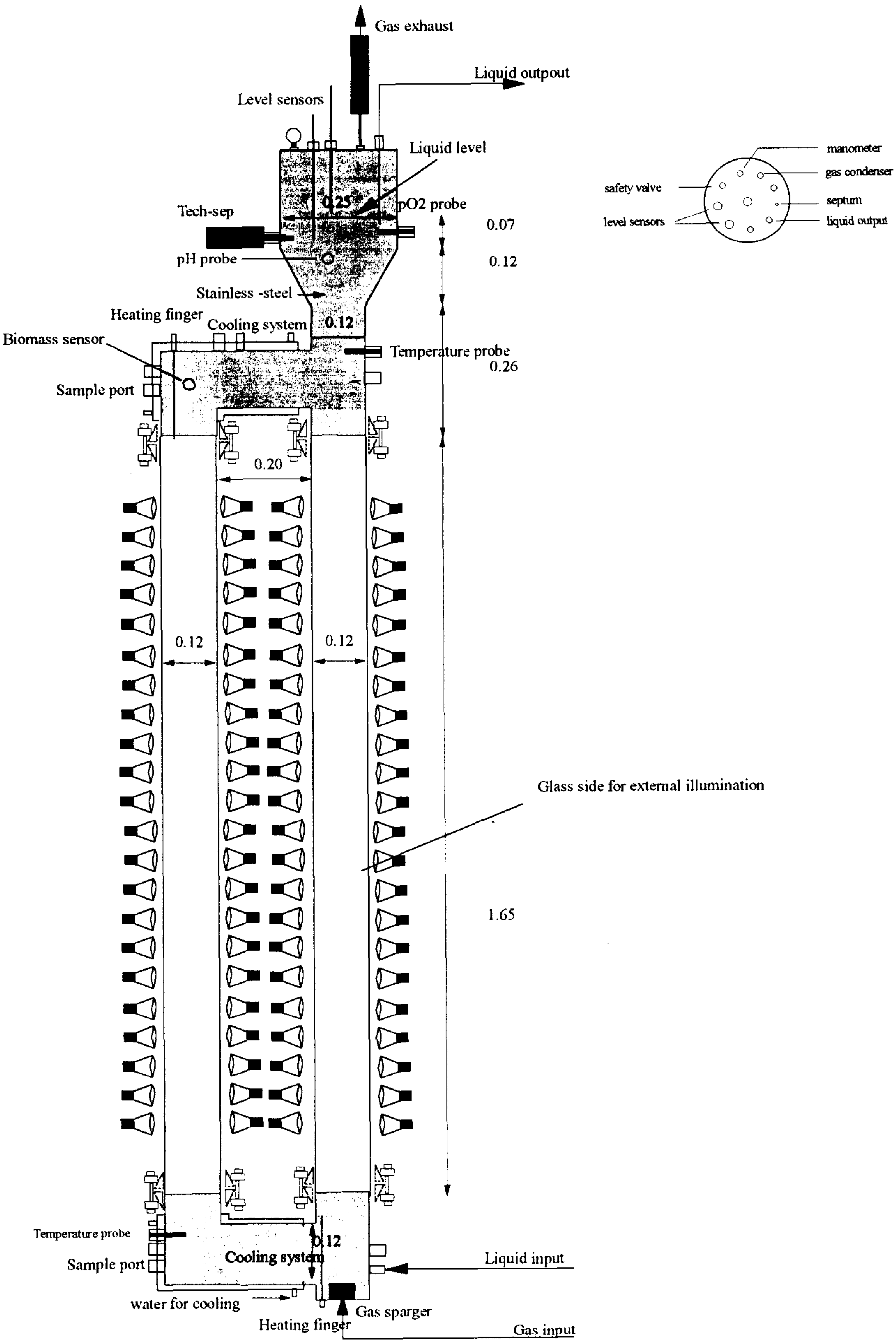


Figure 7. Final proposed airlift design .

To obtain the total useful volume this illuminated volume has to be corrected by a factor taking into account the fact that not all the bioreactor volume will be illuminated. Therefore if we assume that a bioreactor has a 20% of its volume non illuminated, the final volume will be then around 50 l.

Using the actual 7 l bioreactor, the productivity of 6.9 10^{-2} g $\cdot l^{-1} \cdot h^{-1}$ mentioned above is attained at 300 W/m^2 for an illuminated surface of 0.154 m^2 . This corresponds to a production of 0.483 g/h of *Spirulina*. Therefore the total consumed illumination power is of 46.2 W.

At this point the assumption that the power consumed for a certain productivity is constant can reasonably be done. Therefore from the above mentioned values of 46.2W consumed for a production of 0.483 g/h and the new desired production of 3.12 g/h it follows that an illumination power of 300 W (298.9) will have to be supplied to the new bioreactor. Taking a security factor of 15% , the illumination power to supply to the new bioreactor has to be around 350 W of useful light energy. The bioreactor surface will be illuminated with 300 W/m^2, therefore it can easily be calculated that to obtain a total of 350 W the illuminated area required for the new bioreactor has to be of 1.16 m^2.

In conclusion, a bioreactor of 40 l illuminated volume (higher total useful volume, depending on the ratio of illuminated volume vs. total volume), and having an illuminated area of at 1.16 m^2 with an Fr. of 300 W/m^2, will be required. From this data and the basic concept design chosen above, the following final design is proposed.

As represented in figure 7, the final design consists of an airlift bioreactor having a rising tube and an external downcomer both having a 12 cm diameter. The length of this tubes, which constitute the illuminated part of the bioreactor is of 1.65 meters. These two tubes are connected by two stainless steel parts that are double jacketed for temperature control (cooling of the bioreactor is necessary to compensate the thermal energy input from the lamps). The total volume of this bioreactor is of 54 litres (table 7) having an illuminated volume of 37.3 l. This value is slightly below to the 40 l calculated before but on the other hand it has a higher illuminated area, 1.24 m^2 ,instead of 1.16. Moreover this bioreactor has 69% of its total volume illuminated, which represents a significant improvement from the presently used bioreactor which only has a 52% of illuminated volume. This design represents a compromise between the airlift design and the operational specifications. Figure 7 also shows proposed location for the different probes.

	Actual bioreactor	New design
Illuminated volume (l)	3.68	37.3
Illuminated area (m2)	0.154	1.24
Total volume (l)	7	54
Illuminated Vol./Tot. Vol.	0.52	0.69
Illuminated Area/Tot Vol.	21.54	22.9

Table 7 : Comparison of reference parameters of the new bioreactor and the bioreactor currently in operation.

3. Auxiliary equipment.

The event of the construction of a new bioreactor should be used to review the operation of the auxiliary equipment currently used and propose modifications if necessary. In some cases these modifications appear as a consequence of the change in bioreactor scale. As a principle used in this part, the number of modifications should be minimised, and limited to those more important. No modifications are proposed for the equipment working satisfactorily, even that new alternative equipment may be available. In the following the main aspects proposed to review will be addressed.

3.1. Illumination system.

The illumination system is clearly a key element in any photobioreactor. In the present *Spirulina* bioreactor, halogen lamps with variable intensity have been used successfully. The possibility to regulate the light intensity has been a key feature in order to develop an automated control system based on the relationship between light availability and cell growth. Also, the spectra of the halogen lamps was shown adequate to the absorption spectra of *Spirulina* cells (Binois 1994). However, halogen lamps present also important drawbacks. One of them is heat dissipation. The heat produced by the lamps is considerable, making necessary the use of external fans and a cooling system in order to maintain the reactor temperature.

As discussed previously a total of 350W will have to be supplied to the new bioreactor. Taking into account an efficiency of the lamps in converting power energy to light energy of 5% it follows that the total power of the lamps will have to be of about 7000W. If we assume that the same kind of lamps as used before will be used (Sylvania 12V 20W) a total of 350 lamps will be necessary.

3.2. Required power supply for the lamps.

As a source of power for the lamps two possible solutions can be mentioned here. As a first possibility an array of variable power supplies can be used. As the maximum voltage that can be applied to the lamps is 12V and a total of 7000W has to be supplied, the needed power supplies have to provide of total of 583 Amps. The power supplies have to be able to sustain a voltage bigger that 12V to account for the difference of potential loss that will be caused by the wiring. From this specifications it is proposed to obtain the power supplies from the same manufacturer that supplied those currently used (Lambda). The biggest variable power supply this manufacturer is able to supply gives 45 Amps at a 15 Volts. Therefore 13 power supplies will be needed to obtain the 583 Amps.

The wiring of each power supply must hold the 45 A with a minimum resistance to minimise the voltage loses. Assuming normal copper wire is used, a 4.5 mm diameter wire will give a decrease in voltage of 0.5 volts in a 5 metres line, which is acceptable.

As a less expensive alternative it is possible to use a voltage regulator directly on the 220V power line. After this, small fixed voltage converters from 220V AC to 12V DC, can be used. This way when the voltage of the 220V line is regulated a variation in the 12V DC line is obtained.

Final decision on the exact system to implement will be decided after conversations maintained with the ESA technical officer and the lamps supplier.

3.3. Cooling capacity required.

Once the total amount of power to be applied to the bioreactor has been estimated (7000W), the cooling needs can also be estimated.

Assuming that the lamps to use have an efficiency of 5% it follows that 95% of the power (6650W) will be dissipated as heat. Assuming that a proper ventilation system (fan) is available around the bioreactor, this amount of heat will be dissipated in the surrounding air and it will have to be removed by the air conditioning system. Those 6650W are equivalent to 5719 calories/h. As the current air conditioning system is able to remove up to 11200 calories/h, it can be assumed that it will be able to handle this increased amount of heat generation.

On the other hand it can be assumed that the remaining 5% (350W) of energy that has been converted into light will be uptake by the Spirulina culture. Although a part of this 5% energy will be fixed into biomass, the main part of it (about 85%) will be dissipated as heat inside the bioreactor. It can be also considered that as a result of the imperfect aeration around the bioreactor some heat can be transferred from the surrounding air, used to cool the lamps, to the bioreactor. Therefore the above mentioned value of 5% for the heat to be removed from the bioreactor has been increased to 15% to take this effect into account.

It will be assumed that in the less favourable scenario, all this energy is dissipated as heat in the liquid culture. Therefore a liquid cooling system has to be supplied to remove this heat. It is proposed to install double jacketed stainless steel walls for the horizontal parts of the reactor. It should be checked that this will provide enough heat exchange area.

Assuming that the bioreactor must have a temperature of 36 $^{\circ}C$, and that the cooling liquid will enter the coil tubes at 4 ^{0}C and exit with an increase of 10 $^{\circ}C$, a mean logarithmic difference of temperature (DTLM) of 26.7 $^{\circ}C$ can be calculated as the driving force of the heat removal. An overall heat coefficient of 500 $W \cdot m^{-2} \cdot {}^{\circ}C$ can be taken for this system. Assuming that 1050 W of heat energy have to be removed, a surface of $75 \cdot 10^{-3}$ m^2 are needed for the heat exchanger. The surface that can be provided by using a double jacked on the metallic pipes used to connect the two vessel columns is of $150\text{-}200 \cdot 10^{-3}$ m^2 so this is the system proposed for temperature control.

3.4. Liquid flow: pumping and measurements.

In the current bioreactor used in the MELISSA Pilot Plant, liquid inlet and outlet streams are provided by peristaltic pumps. Additionally, no flow measurement is installed on-line, and the operator of the reactor has to check its value at least two times every day. Moreover, the diameter of the tubing in the peristaltic pump changes during continuous operation for long periods. The experiments done with this compartment have shown how sensitive the cell behaviour is with respect to the values of the dilution rate. Also, liquid flow-rate is one of the variables to be modified by the bioreactor control through the GPS, in order to maintain a desired productivity level. Therefore, this aspect should be improved in the design of the new bioreactor in order to have a more robust and reliable operation.

A direct consequence of the increase in bioreactor volume is that, for the usual dilution rates ranges, from 0.01 to 0.05 h^{-1}, the liquid flow-rates will range between 0.5 and 2.5 l/h. Thus, the pumps selected will have to cover this range of flow-rates. With the aim to propose an alternative to peristaltic pumps, two different types of pumps seem adequate: membrane and gear pumps. Centrifugal pumps have been discarded because they are not so indicated for precise flow-rates, and the values required are too low for the usual range of operation of these pumps. The technical information of two different types of membrane pumps (Alldos M 205 Etron M, 205-3.0/E05, and Prominent gamma/4 G/4a-0703) are given in appendix 2. The technical information of Ismatec gear pumps and Tuthill magnet drive gear pumps is given in appendix 3. In both cases there is a suitable size of pumps for the flow-rates required.

The main differences between the two types are, basically, that membrane pumps are very precise (used for dosing liquids), therefore not needing any flow-rate measuring device, but they require maintenance, that is periodic replacement of the membrane heads, and they are expensive. Gear pumps allow continuous operation with low maintenance. The speed of the gear has a lower limit to avoid its blockage, but this should not be a problem for the flow-rates to be used. In this case the pump will have to operate with a flow measurement device in order to have a reliable on-line flow measurement. Both pump types can be regulated by means of analogue input signal, changing the rotation speed of the gear pump or the velocity (strokes/minute) of the membrane pump.

In conclusion, from the comparison of the two types of pumps, the gear pumps seem the preferred option. As a consequence, on line massic measurement devices should be incorporated to the liquid lines. From the different options studied, the equipment proposed for on-line flow-rate measurement is that of Bronkhorst company (see appendix 4). The measurement is based on the thermal conductivity of the liquid. The range of flow-rates that can be measured goes up to 2000 g/h, they are sterilisable and have output electrical signal of 0-5 Vdc or 0(4)-20 mA, that can be used for on-line monitoring of the flow-rates. This is the selected option for flow-rates measurement. A simple alternative of an indirect measurement should be mentioned as well: it consists in the continuous measurement of the weight of the inlet and outlet reservoirs. Variations of their weight with time can be easily translated to flow-rate measurements.

3.5 Liquid level

As important as the liquid flow is the maintenance of a known and constant liquid level due to the fact that in continuous culture the growth rate of the bacteria tends to stabilise at a value equal to the dilution rate, which depends both on the flow rate and the culture volume. Common level sensors based on conductivity hypothetically allow to maintain the culture level between pre-defined limits, situated above the level of the output tube (overflow operation). Usually the level sensors fail in its task to determine the limits of the liquid level. The presence of foam, liquid sprinkling due to aeration, and sticking of biomass on the sensors result in the continuous signalling of high volume to the level control system with the result that the output pump always tries to increase its speed in order to decrease the liquid level. This means that the liquid level sensor system is usually inoperative and the volume is actually maintained at the level of the output culture media tube.

As an alternative to common liquid level sensors, based on conductivity measurements, two interesting systems have been identified.

In the first alternative, a long probe (about 1 m, appendix 5) is introduced in the bioreactor. This probe has two pressure sensors. One remains in the head space of the bioreactor. The other one is located at the tip of the probe. The sensor measures the increase in pressure between those two points, which is due to the pressure of the water column. By maintaining this water column constant the liquid level remains constant. The electronics contained in the probe head supply an output current of 4-20 mA.

In the second alternative (appendix 5), loading cells are located under the bioreactor feet or pedestal. This loading cells transmit the change of the bioreactor weight, allowing to determine the bioreactor liquid volume by determining its weight. The suggested type A can be used up to 300 kg and has a precision of a 0.05% and a repeatability of a 0.01%. Its installation requires to increase the bioreactor height in 81 mm. Final implementation of one of those systems will be decided depending on installation costs and final agreement with the ESA technical officer.

3.6. Gas flows .

Gas supply is also an important subject for the bioreactor design. There are mainly two important points to refer to, which are the quantity of gas to supply, and the measurement of the O_2 and CO_2 concentrations of this gas.

The gas supplied to the bioreactor is used to provide the necessary agitation and recirculation of the culture media. For its proper operation a minimal gas superficial velocity of 5 cm/s is needed. That means that in operating conditions it will be necessary to supply an amount of gas between 30 Nl/min and up to 75 Nl/min if possible. This will be attained by using a gas pump able to overcome the pressure created by the water column, while supplying those air flows.

To measure the O_2/CO_2. production and consumption, in the bioreactor it is necessary to maintain the gas pressure and flow to known, and preferably constant, values. The head space of the bioreactor is maintained at a slight overpressure to prevent microbial contamination, by means of a gas pressure measuring/control system. This pressure is also the same in the gas lines going into the gas analysers.

When in the present configuration the gas loop is closed, aspiration of the gas pump results in a decrease of pressure in the head space of the bioreactor. This pressure decrease is due to the fact that part of the air in the head space of the bioreactor is accumulated in the pipe connecting the air pump and the bioreactor. This is necessary in order to increase the pressure under the water column and be able to overcome it. The air removed can be replaced by temporarily opening a gas valve allowing this way external gas to enter in the part of the loop between the head space of the bioreactor and the pump. Assuming the bioreactor is airtight, once this valve is closed again the pressure before the pump does not decrease again, because no more air is needed to accumulate between the output of the pump and the bioreactor. The only amount of gas that is passing the water column is the one that is being re-circulated around the loop. The pressure at the head space and the gas line accessing the gas analysers can be slightly increased and maintained constant by locating a gas flow controller between those gas analysers and the input gas pump. However if the bioreactor has any leak of air, an extra gas input will be needed.

It must be mentioned that if the liquid level is maintained by means of a tube that reaches the liquid surface and a pump that works at a slightly higher flow than the input pump, that is by overflow of liquid, the output pump is also removing, in addition of the culture media, part of the head space gas resulting in a loose of the oxygen enriched gas. The availability of a more efficient liquid level sensor system, would allow to avoid this gas loss. In that case the liquid output tube would be immersed in the liquid and the gas loss in the head space would be avoided.

3.8. Control system.

For the proper work of this bioreactor it is necessary to incorporate it in the actual control system network. For this purpose there are available four controllers, of the same type as the ones currently being used (MICON P100). Unfortunately two of them are out of order. As the production of this controllers has been discontinued in favour of more updated models, the only remaining possibilities are either to repair the old ones or to upgrade to new models. The repair of the old ones appears possible, if spare parts can be found, but this option is nearly as expensive as to buy new ones. However buying new ones requires also to upgrade corresponding control the software, because the old version currently being used does not support the new controllers. In any case the upgrade of the system will have to be done in the near future because spare parts will no longer be available and the replacement of the controllers for new ones requires a software update.

For those reasons, conversations have been initiated with a manufacturer (ASTARE) in order to buy 4 new controllers, to be used in this new bioreactor, and to upgrade the control software. An estimation of the cost of the operation is included in the estimation costs of the equipment. The final decision will be taken after ESA approval.

3.9. Other considerations.

As already mentioned, it is proposed to keep the peripheral equipment that have already been used satisfactorily. However, in some cases this peripheral equipment will also be required for the current air-lift bioreactor to work in the compartment II experiments. In addition, the equipment for basic measurement (and control) such as level, pressure, temperature, pH, pO_2, will also be revised. New equipment purchased when the currently used probes will be required for compartment II. Finally, the equipment for on-line measurement of nitrate concentration already used, will also be used for the new bioreactor.

3.10. Economic evaluation.

From preliminary contacts with the suppliers of the equipment, the following economical evaluation of the cost of the set up of the new bioreactor can be done.

ITEM	COST (ptas)	COST (AU)
Reactor	7.000.000	41.200
Lights and light support	1.000.000	5.885
Cooling bath	1.000.000	5.885
DO and pH control system	1.000.000	5.885
CO_2 mass flow meter	250.000	1.471
Gas loop (pump and pressure measurement system)	750.000	4.414
Liquid pumps	850.000	5.003
Liquid flow meters	250.000	1.471
Power supply	4.000.000	23.542
Controllers and software	3.500.000	20.599
Contingencies	1.000.000	5.885
Total	20.500.000	120.654
taxes (16%)	3.500.000	20.599
Total estimated final cost	23.800.000	140.077

Final remarks.

In this TN a basic definition of the proposal for a new bioreactor for MELISSA compartment IV is presented. Once approved by ESA its set up will be done in two phases. In the first one the final design will be discussed with the manufacturer, in this case Bioengineering. Once accepted for the manufacturer, it is expected a delivery time of around three months. Once the bioreactor will be delivered a second installation phase will be started. During this second phase the control system wiring and tubing connections will be performed. Once completed this second phase the bioreactor will be ready for operation and the experiments currently being done in another airlift will be continued in the new one.

References.

BINOIS, C. 1994. Automatisation d'un écosystème artificiel utilisé commme système de support de vie. Première intéraction du modele/système de contrôle. ESTEC-ESA contract CCN5. Final Report.

De CHAMBURE, D. 1992 Determination of respiratory activity of rats fed on *Spirulina* enriched diets. ESTEC test report YCV/932.DDC/if.

CHISTI, Y. 1989. "Air lift bioreactors", Elsevier, Barking (England).

CHISTI Y., YOUNG M. 1993. Improve the performance of airlift reactors. Chemical Engineering Progress 89 (6) : 38-46.

CORNET J.F., DUSSAP C.G., GROS J.B. 1993. Modelling of physical limitations in photobioreactors. MELISSA Technical Note 19.1. ESTEC-ESA contract PRF 130820.

CORNET J.F., DUSSAP C.G., GROS J.B. 1993b. Modelling of physical limitations in photobioreactors. MELISSA Tecnical Note 19.2. ESTEC-ESA contract PRF 130820

TRANQUILLE, N. ; EMEIS ; J. 1992 Food acceptability studies for MELISSA. Final Report ESTEC Contract 113088.

APPENDIX 1

BIOENGINEERING
Bioengineering AG CH-8636 Wald

Offerte
Quote 8812
Offre

Prof. F. Godia
Unitat D'Enginyera Quimica
Facultat de Ciencies
Universitat Autonoma de Barcelona
E-08193 Bellaterra - Barcelona

Dear Professor Godia

We are pleased to submit you our quotation for

Bioengineering
Loop Reactor

CH-8636 Wald, Switzerland
December 3rd 1996 / MB

BIOENGINEERING
Bioengineering AG CH-8636 Wald

I **FERMENTER**

Loop Reactor
based on two units of Visual Safety Airlift-Reactor

Sterilizable in situ
basic equipment similar to our description, including

Vessels (each)	26 litres total volume (total volume of Loop: approx. 53 litres) cylinder of transparent foil, inside diameter 150 x 1500 mm, steel jacket for in situ sterilisation (empty), sampling tube with hypodermic needle The vessels are connected by stainless steel pipes to a loop, cooling elements are integrated in the connections. On top of the aerated vessel an air separation chamber is mounted with possibility of level control (optional). Probes can be mounted on top of the vessels and do not reach the illuminated (transparent) part of the vessel.
Lid	stainless steel 1.4435 with sterile and pressure proof ports diameter 19 mm, pressure relief valve and manometer (only for one vessel)
Circulation	by air (Airlift)
Aeration	(only for one vessel) pressure control valve, rotameter, check valve, aeration filter (ceramics) in housing (stainless steel), hypodermic needle and aeration tube with ring sparger required air pressure 2 - 7 bar
Ventilation	(only for one vessel) exhaust air filter (ceramics) in housing (stainless steel) with pressure holding valve
Power Supply	220V / 50Hz

Measurements and Controls

Include an instrument cabinet with tiers 19" high. It accommodates all control loops ordered including

BIOENGINEERING
Bioengineering AG CH-8636 Wald

Temperature Control

Sterilizable Pt100 probe, measuring instrument with temperature range 0 -150 C, digital display, temperature controller for heating (during sterilisation) and cooling with two set points for cultivation and sterilization temperature.
Controller parameters are programmable through front keyboard.
All necessary in- and outputs, signal 4-20 mA, for data registration and external set point control.

Price for complete loop as described above **CHF** **68'000.--**

BIOENGINEERING
Bioengineering AG CH-8636 Wald

IV CONDITIONS

Delivery Time offered

approx. 4 months following receipt of your written order containing all necessary technical data or on agreement.

Payment

Within 30 days from date of invoice, strictly net, without any discount, by bank transfer to Union Bank of Switzerland, Uster branch, CH-8610 Uster/Switzerland, Account No. 814.400.01 N

Terms

Prices are net, ex works, excluding wrapping, without any deduction, excluding V.A.T., according to our General Conditions of Supply, dated 1991, issued by the Swiss Association of Machinery Manufacturers, as per enclosure.
Connection to services and energies such as electricity and mains, installation, commissioning, not included.

Warranty

1 year, as per Item 13 of the General Conditions of Supply dated 1991, issued by the Swiss Association of Machinery Manufacturers, as per enclosure.

Installation/Operations Manual

Each Bioengineering fermenter is backed up by

a Manual in English explaining in detail the erection, hook-up to services, start-up, commissioning, maintenance and safety aspects,

a Spare Parts and Accessories Catalogue in English showing in detail with a reference number, a photograph, and a technical explanation all parts available for the unit supplied.

Validity

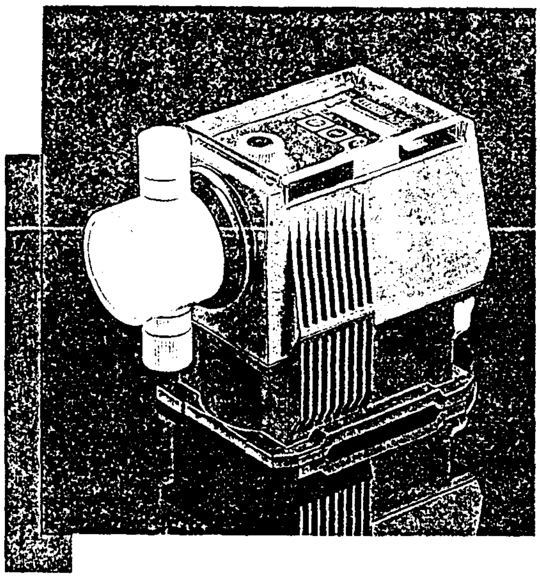
This quotation and its prices and terms are valid until March 3. 1997

Yours sincerely

Bioengineering AG

Matthias Bally

APPENDIX 2



ALLDOS **Dosing equipment**

Microcontroller - Diaphragm Dosing Pump M 205 Etron M

Construction and function

The new diaphragm dosing pump M 205 Etron M is a reciprocating displacement pump equipped with an efficient electric motor and microcontroller electronics for diverse control applications.

The pump is driven by an overload - proof synchronous motor. The rotation of the motor is transformed into the suction and stroke movements of the diaphragm by a precise eccentric - tappet - spring system, secondary to the gears.
Thus a defined volume (stroke volume) of the dosing medium is sucked up via the suction valve into the dosing head and displaced through the pressure valve into the dosing line.

The suction and pressure valves are reliable double ball valves.

Mechanical variation of the stroke length at the stroke adjustment knob enables linear adjustment of the dosing output in the ratio 1 : 10.

The integrated microcontroller electronics facilitate the application of the pump to nearly all control tasks occurring in liquid dosing techniques.

The dosing pump can be configured by the customer to the required function via the alphanumeric display with multilingual operator prompting and only four operator buttons (function chart see overleaf).

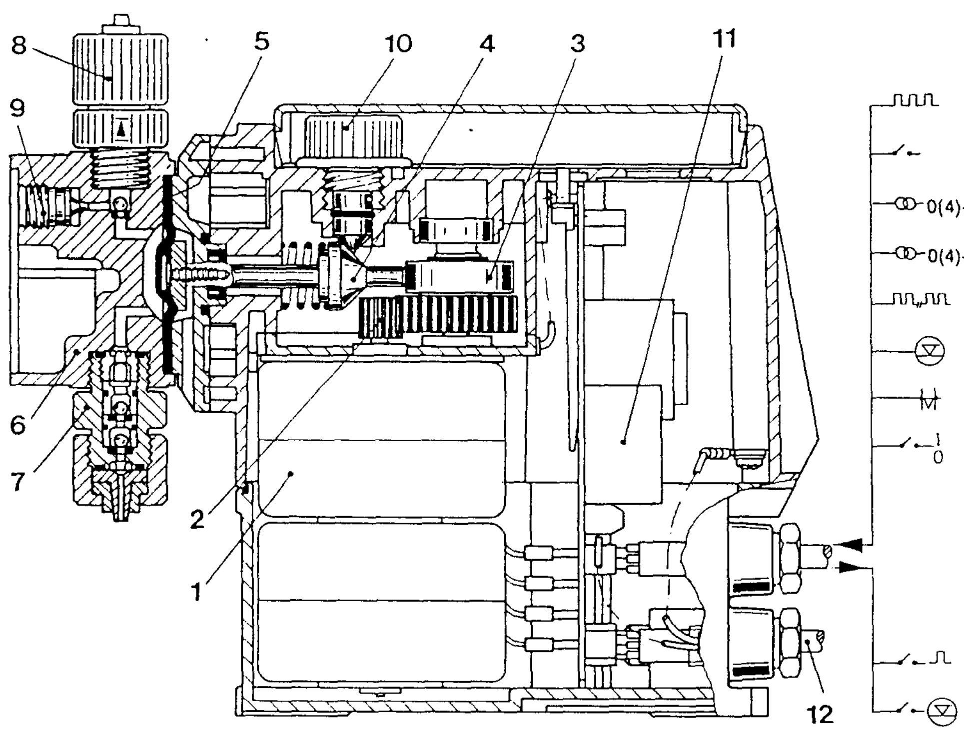
Mains cable and mains plug are standard equipment of the pump.

Design variants

The pump variant described in this product information is available in different material combinations of dosing head and valves as well as for different supply voltages.
The pump series M 205 also includes a standard version without electronics and two electronic versions for simple control applications.
For these versions refer to the product information 1.2/205-01.

Advantages at a glance

- high control function flexibility due to the capable microcontroller electronics
- high dosing precision and linear dosing characteristic
- harmonic dosing process thanks to the electric motor preventing pulsation strokes
- optimal for application in humid locations due to the high degree of protection of the pump
- ideal for the use in laboratories due to the low - noise operation and chemically resistant pump enclosure
- universally resistant, PTFE - coated dosing diaphragm
- easy start up by integrated dosing head deaeration with ecologically beneficial medium recirculation into the dosing receptacle



1 - Motor		*5 - Dosing diaphragm*		*9 - Dosing head deaeration*			
2 - Gears		*6 - Dosing head*		*10 - Stroke adjustment knob*			
3 - Eccentric		*7 - Suction valve*		*11 - Electronics*			
4 - Tappet		*8 - Pressure valve*		*12 - Mains cable*			

Function chart / diaphragm dosing pump M 205 Etron M

- Display - operator prompting selectable in German, English or French
- Mains frequency adjustable to 50 or 60 Hz
- Configuration error detection with error indication on the display

Basic functions

Manual control
- Continuous operation, stroke frequency selectable 1 - 121 strokes / min. with 50 Hz and 1 - 145 strokes / min. with 60 Hz
- Batch dosing, stroke frequency per batch selectable 1 - 10.000

Pulse signal control
- Proportional dosing, multiplication or devision factor of the input contacts freely selectable
- Batch dosing, stroke frequency of the batch per input contact selectable 1 - 10.000

Current signal control
- Proportional dosing, input signal range 0 - 20 mA or 4 - 20 mA and 20 - 0 mA or 20 - 4 mA selectable

Measured value dependent control
- setpoint of the controlled variable adjustable
- weighting factor for actual value, proportional factor K_p, reset time T_n, control direction, control response (linear or logarithmic) selectable

General technical data

Accuracy	dosing flow ± 1,5 % / linearity ± 4 %
Suction height*	6 m water gauge (except for 205-0,2)
Materials	parts in contact with media: PP / Viton, PVDF / PTFE, steel 1.4571 / Viton dosing diaphragm: PTFE - coated
Drive	synchronous motor optionally 230 V, 110 V, 240 V or 120 V, 50 / 60 Hz, 8,9 W (up to 205-5,0), 23 W (205-6,0 / 205-10 / 205-14)
Protection	IP 65 (degree of pump protection)
Weight	ca. 2,8 kg
Colour	RAL 6017 (May green) / black
Dosing head - connections	all types except 205-10 and 205-14: DN 4 for PE / PVC - hose 4/6, PVDF - tube 4/6, steel - tube 4/6 205-10 and 205-14: DN 8 for PVC - hose 6/12 or PP - tube DN 10 (16 x 2), PVDF - tube DN 10 (16 x 2), steel tube 1/4"
Signal inputs	contact signal input, max. load 5 mA 2 current signal inputs, input load each 22 Ω input for remote On / Off, contact load 5 mA input for dosing controller (NAMUR) input for receptacle empty indication (ALLDOS - empty indication sensor)
Signal outputs	stroke signal output, max. load 250 V / 2 A (ohmic load), contact time 250 msec. / stroke output empty indication, max. load 250 V / 2 A (ohmic load)

** Referring to media not viscous and not outgassing*

Version: dosing head and valves of PP, operating voltage 230 V (+ 6 % / - 10 %), 50 / 60 Hz, with microcontroller electronics E05

Order number	Stroke cm³	50 Hz l/h	50 Hz bar	50 Hz s/min	60 Hz l/h	60 Hz USg/h	60 Hz bar	60 Hz psi	60 Hz s/min
205-0,2 / E05	0,04	0,3	10	121	0,36	0,095	10	145	145
205-0,8 / E05	0,14	1	10	121	1,20	0,317	10	145	145
205-1,6 / E05	0,22	1,6	10	121	1,92	0,51	10	145	145
205-3,0 / E05	0,42	3	10	121	3,90	1,03	6,8	100	145
205-5,0 / E05	0,69	5	6	121	6	1,58	5	72	145
205-6,0 / E05	0,84	6	8	121	8	2,11	6	90	145
205-10 / E05	1,24	9	6	121	11	2,90	5,5	80	145
205-14 / E05	1,92	14	4	121	17,2	4,54	3	45	145

Range of further materials for dosing head and valves

Ref. no.*	Material (body / gaskets / valve ball)
D02	1.4571 / PTFE / 1.4401 without deaeration valve
D03	PVDF / PTFE / ceramics with deaeration valve
D57	1.4571 / PTFE / 1.4401 with deaeration valve

** When ordering these versions indicate their reference numbers*

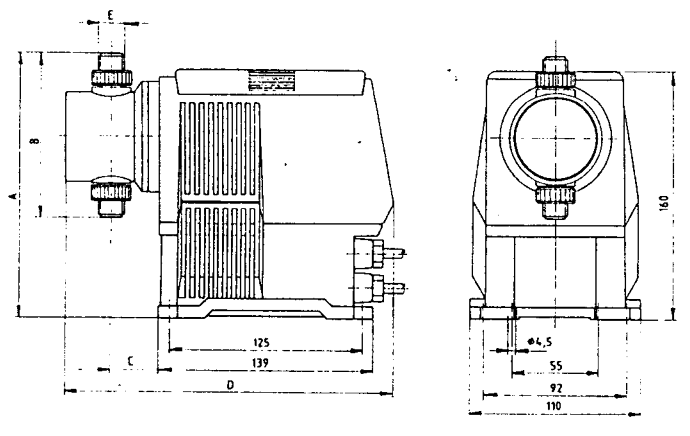
Range of further mains voltages

Ref. no.*	Data
V00	230 V (+ 6 % / - 10 %), 50 / 60 Hz
V01	110 V (+ 10 % / - 10 %), 50 / 60 Hz
V02	240 V (+ 10 % / - 10 %), 50 / 60 Hz
V06	120 V (+ 10 % / - 10 %), 50 / 60 Hz

** When ordering these versions indicate their reference numbers*

Signal transmission cable, 4-core, length 2 m, including circular connector for the panel jack of the pump

Order no.	
321-205	for control signal input and remote On / Off
321-206	for potential-free output for empty indication and stroke signalling



Pump type	Measurements in mm				
	A	B	C	D	E
205-0,2 to 205-6,0	170	108	30	211	R 3/8"
205-10 and 205-14	182	131	36	213	R 5/8"

Technical data subject to change without notice

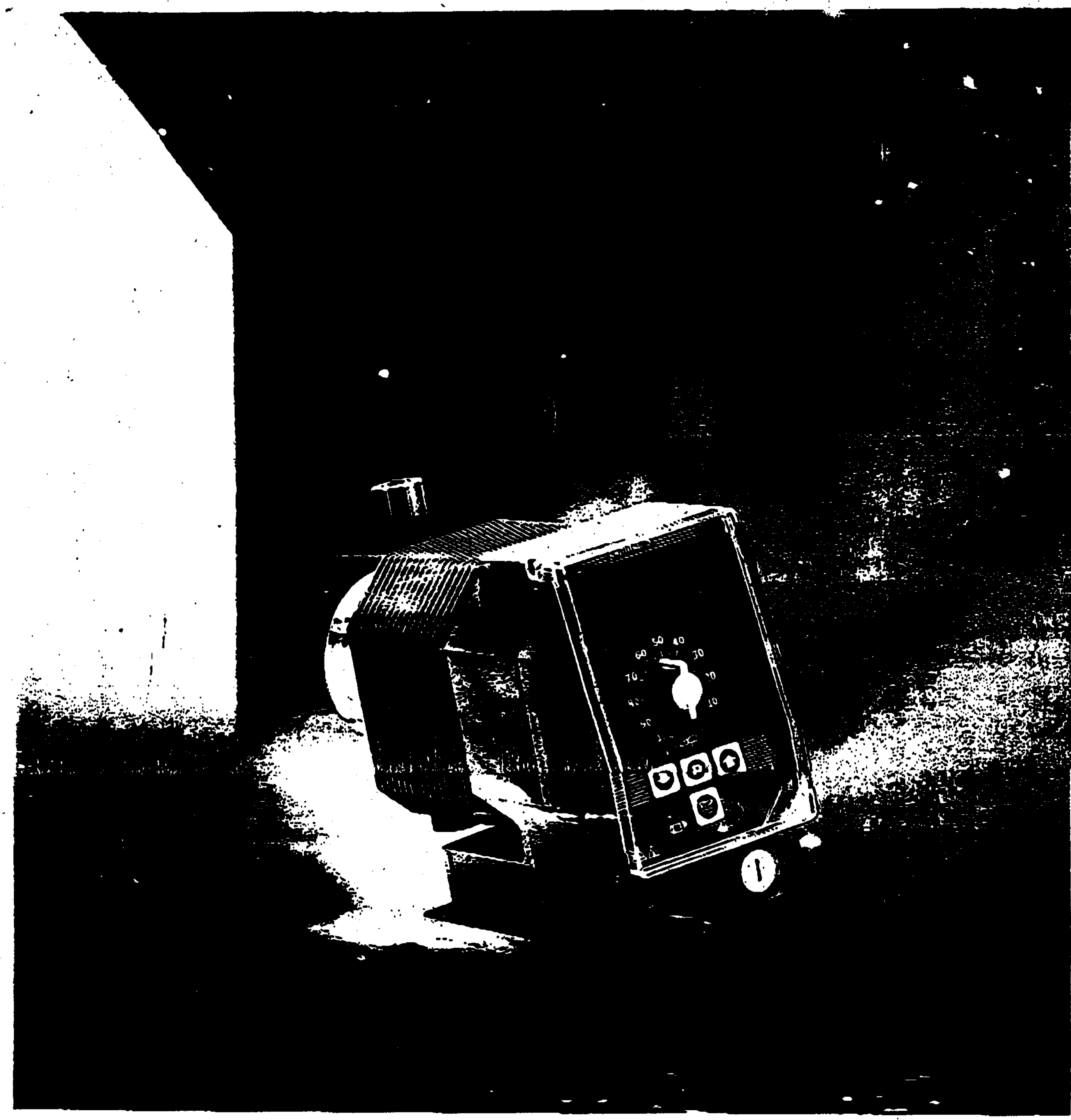
ALLDOS

ALLDOS Eichler GmbH
Reetzstr. 85 · D-76327 Pfinztal (Söllingen)
Postfach 12 10 · D-76318 Pfinztal
Tel. (0 72 40) 61-0, Fax (0 72 40) 61 177
Tx. 7 826 524 dos

ProMinent® gamma.

Un sistema de dosificación inteligente, programable e interactivo.

Gamma/4 y gamma/5: la nueva generación de bombas dosificadoras electromagnéticas interactivas ProMinent® (versión "a"), controladas por microprocesador, que garantiza una gran seguridad en la dosificación en el rango de candales desde 0.01 ml/impulso a 30 l/hora. gracias al control automático del caudal y a la identificación de fallos, incluso de perturbaciones externas.

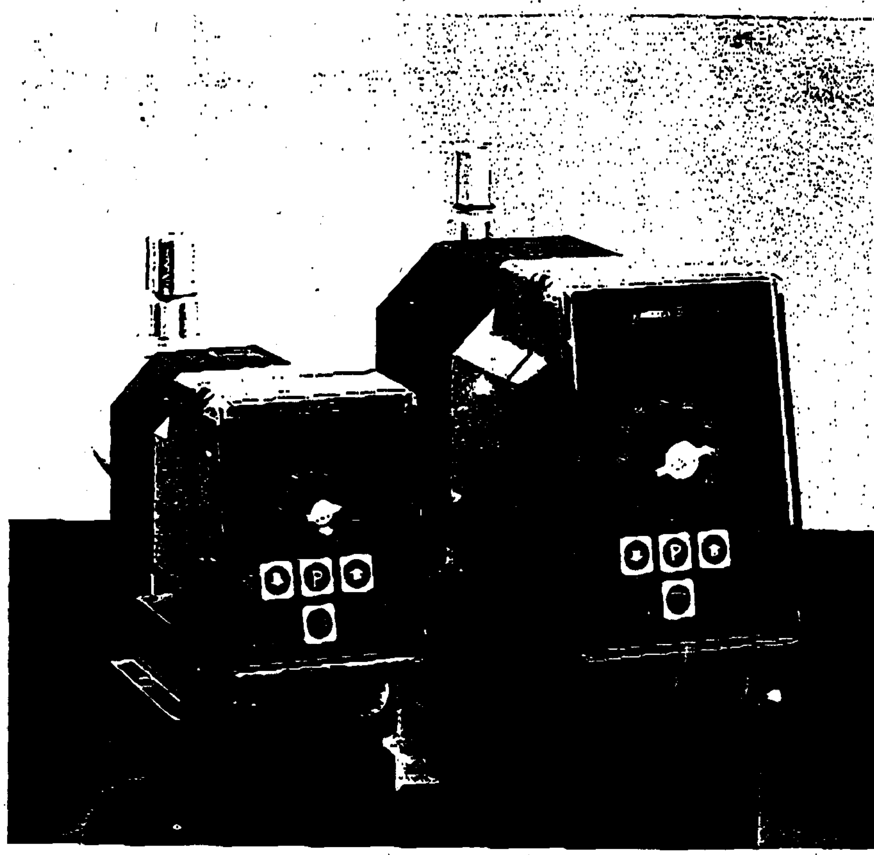


ProMinent

Dosificación de líquidos y Técnica de regulación exacta.

ProMinent gamma:
La facilidad de manejo y la seguridad de funcionamiento garantizan un proceso óptimo.

Las bombas ProMinent® gamma son bombas electromagnéticas de membrana, controladas por microprocesador, que se utilizan para la dosificación de líquidos. Estas bombas combinan componentes mecánicos de probada eficacia y la más moderna técnica de control. A partir de la experiencia acumulada durante varias décadas como empresa líder en el mercado de bombas dosificadoras electrónicas, y de las exigencias de los usuarios, ProMinent® ha desarrollado una generación completamente nueva de bombas dosificadoras. Las bombas gamma/4 y gamma/5, y la bomba dosificadora de precisión mikro g/5, son de fácil manejo, gracias a indicaciones en texto no cifrado. El diagnóstico de fallos, incluso de perturbaciones externas, garantiza la máxima seguridad de funcionamiento. Las bombas ofrecen posibilidades de adaptación prácticamente ilimitadas para los sistemas de automatización de procesos, garantizando una elevada seguridad de dosificación.



Componentes mecánicos

La carcasa

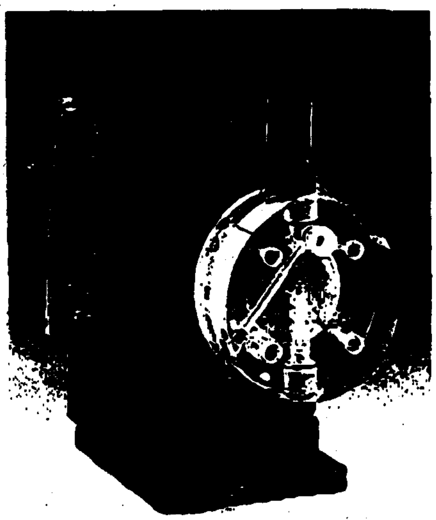
Diseño estético y funcional, de material sintético reforzado con fibra de vidrio, clase de protección IP65. Esto garantiza una gran protección contra productos químicos, así como contra posibles manguerazos. Además, la carcasa de la bomba ProMinent® gamma es robusta, resistente a los golpes y de peso reducido.

El accionamiento magnético

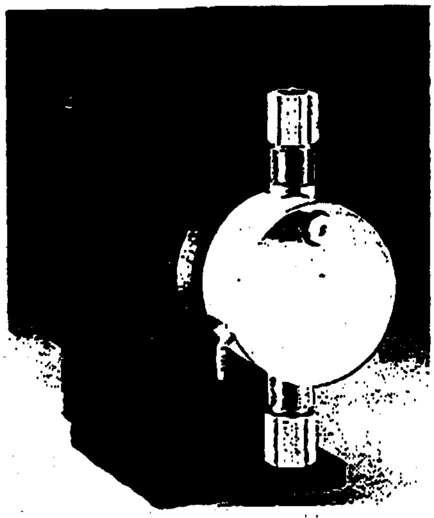
Los sistemas convencionales de accionamiente de una bomba consisten en un motor eléctrico y engranajes, con un gran número de piezas móviles. El accionamiento electromagnético de ProMinent®, en cambio, cuenta con una única pieza móvil: el inducido del electroimán. En el caso de la bomba ProMinent® gamma, se trata de un electroimán de carrera corta con un recorrido máximo de 1,25 mm, que no exige ningún tipo de mantenimiento. La bomba incorpora, asimismo, un moderno sistema de amortiguación de ruidos, que garantiza un funcionamiento silencioso. El ajuste de la longitud de la carrera está acoplado directamente al electroimán. De esto modo, se obtiene una máxima precisión en el ajuste de la carrera, sin retención ni desajuste involuntario.

La membrana dosificadora

La membrana dosificadora DEVELOPAN® está fabricada en material EPDM de alta calidad, reforzado con malla de Nylon, con el núcleo de acero vulcanizado y estás recubierta de Téflon en la parte en contacto con el líquido. La combinación de estos materiales asegura una amplia vida útil a la membrana. La membrana dosificadora DEVELOPAN® de ProMinent® es resistente a casi todos los productos químicos y puede utilizarse en un amplio rango de temperaturas, admitiendo contrapresiones de hasta 16 bar.

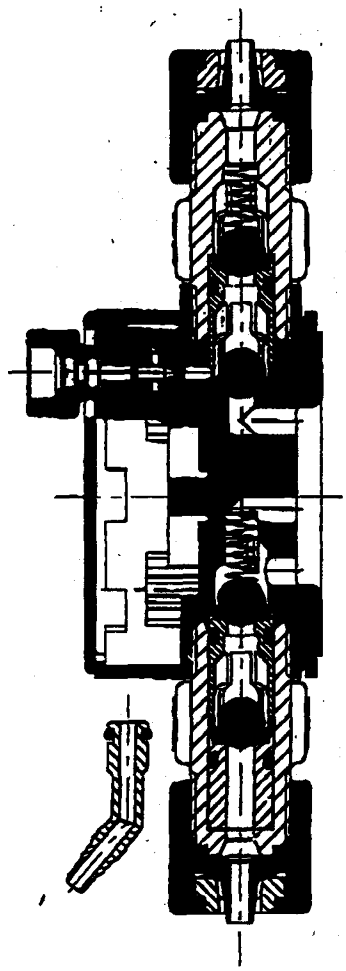


(NP)

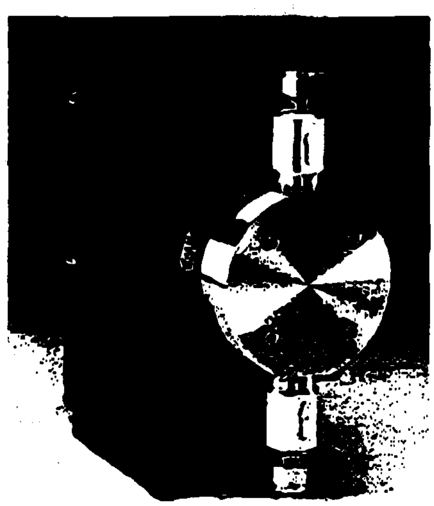


(PP)

(TT)



(Seccion transversal del cabeza! en PP)



(SS)

El cabezal dosificador

Los cabezales dosificadores de las bombas ProMinent® gamma pueden suministrarse en cuatro materiales diferentes:

- polipropileno (PP)
- Plexiglas (NP)
- Teflón (TT)
- acero inoxidable 1.4571 (SS)

Se han incorporado válvulas de doble bola en la aspiración e impulsión. Los cabezales dosificadores del tipo 1000-0417 PP y NP cuentan, asimismo, con una válvula combinada de purga de aire para facilitar la aspiración cuando la bomba se pone en marcha. Además, la válvula está provista de un dispositivo de ajuste fino, que controla la desaireación automática en continuo, p. ej. cuando se dosifican líquidos que producen gases. (Los tipos 0423 y 0230 están equipados con válvulas de una bola y no llevan la válvula de purga de aire.)

Los cabezales dosificadores de la serie HV, fabricados en polipropileno "PP4", han sido diseñados especialmente para líquidos altamente viscosos. Disponen de una mayor sección de paso de líquido, e incorporan válvulas de una bola más grandes, sometidas a la presión de un muelle.

Amplio rango de voltajes

Las bombas dosificadoras gamma se suministran en dos versiones principales: 230 y 115 voltios, que admiten amplias variaciones de voltaje: de 195 hasta 265 V en el rango superior, y de 98 hasta 132 V en el inferior, para una frecuencia de la red de 50 o 60 Hz. La versión de 230 V puede suministrarse con enchufe plano, suizo o australiano; la versión de 115 V, con enchufe de EE. UU.

NUEVO: TÜV-GS

TÜV PRODUCT SERVICE GS geprüfte Sicherheit

Las bombas dosificadoras gamma tienen la garantía de comprobación TÜV GS y han sido homologadas según la norma DIN-VDE 0700 y además, cuentan protegidas contra las interferencias vía radio, clase, B, según norma DIN-VDE 0871.

Gracias al control por microprocesador.

Se puede ampliar el rango de funciones de las bombas dosificadoras de la serie ProMinent® gamma en función de las exigencias específicas del cliente. La versión básica satisface los requerimientos planteados en un gran número de aplicaciones. Si se requieren prestaciones adicionales, se puede incorporar a la versión escogida el correspondiente tipo de control y las funciones opcionales deseadas.

LA VERSIÓN BÁSICA

El rango de ajustes

Operación en continuo

Se pueden regular manualmente el caudal del 100% al 10%, variando la longitud de recorrido mediante un mando giratorio, y, mediante un pulsador, la frecuencia de impulsos "f" desde 120 (100) hasta 1 impulso/minuto, es decir, en el rango 1:1.200 (1:1.000). El número de impulsos/min. seleccionado está indicado. Se incorporan cristales de cuarzo que mantienen con muchísima precisión la frecuencia de los impulsos.

Control externo "Contact"

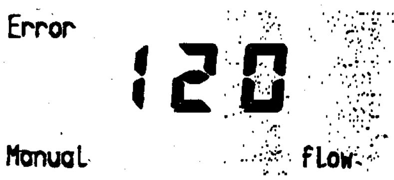
La frecuencia de impulsos de las bombas dosificadoras ProMinent® gamma se puede controlar mediante contactos externos, p. ej. por medio de los de un contador de agua. Para ello hay que conectar el cable de control externo a la entrada de contactos de la bomba. Cada impulso recibido (contador de agua o regulador de frecuencia) da un solo impulso a la bomba. La bomba admite un máximo de 120 impulsos/min. No se tiene en cuenta ninguna frecuencia de impulsos que exceda esta cantidad, evitándose, por lo tanto, cualquier sobreexcitación de la bomba.

Control de nivel "Minimum"

Se puede conectar en el correspondiente terminal un control de nivel ProMinent® de dos etapas para controlar el nivel del líquido. Cuando se alcanza un cierto nivel mínimo, se activa una señal de alarma preventiva. En este caso, se pone en intermitencia la indicación "Minimum" y se enciende el indicador LED rojo y se activa el relé opcional de aviso de fallos, pero la bomba dosificadora sigue funcionando. La bomba se detiene sólo cuando el nivel en el depósito dosificador ha bajado otros 20 mm. Entonces se encienden las indicaciones "Error" y "Minimum". El relé opcional de aviso de fallo continúa cerrado.

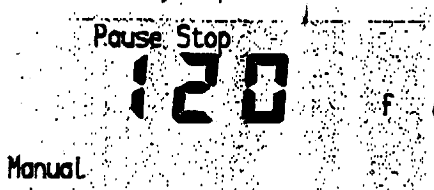
Control de caudal "flow"

La misma bomba dosificadora gamma controla el caudal de dosificación. Se puede instalar en el cabezal dosificador una alarma regulable para controlar el caudal. Una vez conectada, capta cada impulso completo de la bomba, dando una señal de realimentación al circuito electrónico de la misma. Cuando esta señal de realimentación, que indica el caudal correcto, falta durante 8 impulsos seguidos, la bomba se para y se encienden las indicaciones "Error" y "flow" en el display digital, así como el indicador LED rojo.



Conexión adicional "Pause"

La bomba gamma se puede conectar y desconectar, sin potencial, a través del cable de control. Esta función trabaja según el principio de corriente en reposo, es decir, cuando los contactos se abren, la bomba se para y se encienden las indicaciones "Pause" y "Stop".



Autorregulación

El sistema de mando electrónico de la bomba gamma se autocontrola de manera automática y permanente. En caso de registrar algún fallo de sistema en el microprocesador, la bomba se desconecta y se activa una señal de alarma. Se ponen en intermitencia todas las indicaciones en el display digital y se enciende el indicador LED rojo.

Diferentes tipos de control y funciones opcionales. Ud. puede elegir el tipo de bomba que satisfaga sus exigencias personales.

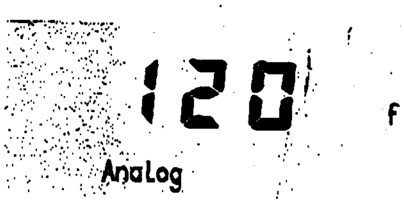
CONTROLES ADICIONALES Y FUNCIONES OPCIONALES

Iluminación

Se puede iluminar por detrás el display digital, lo que hace posible una perfecta legibilidad de las indicaciones, incluso en condiciones deficientes de luz o en caso de montaje en un sitio desfavorable. Todos los controles adicionales y las funciones opcionales se pueden suministrar por separado o como paquete combinado libremente.

Analog Control (control analógico)

Se pueden emplear señales analógicas para controlar de forma proporcional la frecuencia de impulsos entre 0 y 100%, dependiendo de la señal (0/4-20 mA). Se puede ajustar el número máximo posible de impulsos por minuto. Si se utiliza una señal analógica de 4-20 mA, la bomba se para y se activa la alarma cuando la señal de entrada es inferior a 4 mA (p. ej. en el caso de rotura de cable). Al formular el pedido, se pueden solicitar otras señales de entrada (0-1 V, 0-10 V, 0-60 mV), mediante el código especial de identificación.



Pulse Control (control de impulsos)

Adapta la bomba ProMinent® gamma a cualquier tipo de generadores de impulsos. No es necesario disponer de otras unidades de control. Las siguientes funciones pueden ajustarse mediante pulsadores:

Multiplicación y División de impulsos

La multiplicación y división se define entrando un factor entre 0,01 y 9999. p. ej.:
división-entrando con el factor

0,01: (100 impulsos externos = 1 impulso de la bomba)
0,25: (4 impulsos externos = 1 impulso de la bomba)
1: (1 impulso externo = 1 impulso de la bomba)

Multiplicación – entrando el factor

4: (1 impulso externo = 4 impulsos de la bomba)
9999: (1 impulso externo = 9999 impulsos de la bomba)

Contador de preselección "N —"

El número de impulsos preseleccionado, p. ej. 20 (máx. 9999) se activa mediante un contacto libre de potencial o el pulsador P, indicándose el número de impulsos pendientes en el display digital.

Memoria "Mem."

Se puede conectar adicionalmente una memoria intermedia, con una capacidad de almacenamiento de 65.535 (2^{16}-1) impulsos. Si la frecuencia de los impulsos recibidos es superior a la frecuencia máxima de la bomba, éstos quedan almacenados y la bomba continúa dosificando hasta finalizar la secuencia. Es decir, se puede emplear una bomba dosificadora de menor capacidad en algunas aplicaciones. Esto es un ejemplo concreto de cómo se pueden minimizar los costos.

Contador de impulsos "N"

Totalizador del número de impulsos, hasta un máximo de 19998 impulsos.

FUNCIONES OPCIONALES

Temporizador

Esta función permite programar hasta 31 tiempos de dosificación, con reiteración diaria o semanal y con intervalos de 1 minuto a 24 horas. Se utiliza p. ej. para la dosificación automática de microbicidas, para tratamientos de choque en la industria del papel y en torres de refrigeración contra la formación de algas y limos.

Salida de relé

Sirve para la teletransmisión de señales, p. ej. del aviso de fallo a la central de mando, o bien para el control externo de p. ej. una segunda bomba dosificadora ProMinent® que trabaja en régimen sincronizado. Posibilidades de ajuste:

Alarma general

Alarma previa del control de nivel y desconexión final de la bomba, control de dosificación, fallos del sistema, aviso de fallo de los fusibles y de la red. Principio de funcionamiento: el relé vuelve al estado de resposo en caso de alarma (normalmente cerrado).

Relé de alarma

Alarma previa del control de nivel y desconexión final de la bomba, control de dosificación, fallos del sistema. El relé se excita en caso de alarma (normalmente abierto).

Relé generador de impulsos

Con generación de impulsos paralelos a cada impulso del electroimán de la bomba; duración del contacto: 150 mseg. La función deseada debe especificarse en el pedido.

OTRAS VERSIONES:

Tensión reducida 12/24 V y versión RS

Disponemos de las versiones g/4-W y g/4-I de la gamma/4 para tensiones reducidas de 12 V c. c. y 24 V c. a./c. c. y de la versión g/4-RS con interfase serie RS 232 para control a través de los ordenadores del cliente. Las gamma G/4a para tensiones reducidas, G/4a y G/5a para control por ordenador con interfase RS 232/RS 485 se encuentran en vías de preparación.

ProMinent Remote Control

La combinación ProMinent® Remote Control, compuesta por una bomba dosificadora gamma G/4Ra o G/5Ra y un mando a distancia, permite controlar y operar la bomba desde una distancia de hasta 100 m.

ProMinent mikro g/5

Es una bomba dosificadora interactiva de precisión, controlada por microprocesador, de uso en laboratorios y la industria. La carcasa, el manejo y las opciones de la mikro MG5a son idénticos a los de la gamma G/5a. Tiene un rango de caudales desde 1 µl/impulso a 1500 ml/hora; la presión de trabajo máx. es de 40 bar y la precisión de dosificación es superior a ± 0,5%. Les facilitaremos gustosamente información más detallada, si Vds. la solicitan.

El sistema mediante códigos de identificación facilita el pedido de las bombas dosificadores ProMinent® gamma.

[redacted]

[redacted]	PP 1	0	0	0	A	0	0	0	0	0

[redacted]

Material del cabezal dosificador:
PP 1 = polipropileno con juntas de EPDM
PP 2 = polipropileno con juntas de Viton
PP 4 = polipropileno HV para líquidos altamente viscosos con juntas de EPDM, y muelles de Hast. C en las válvulas: sólo para 1002, 1005, 1310, 0813
NP 1 = Plexiglas con juntas de Viton
TT 1 = Teflón grafitado con juntas de Teflón
SS 1 = acero inoxidable 1.4571 con juntas de Teflón
SS 2 = acero inoxidable con rosca R 1/4" NPT
SK 1 = acero inoxidable con conexión capilar R 1/8", sólo para G/4 a 1000, 1601, 1201

Muelles en las válvulas:
0 = sin muelle
1 = con 2 muelles en las válvulas 1.4571 0,1 bar

Conexión:
0 = standard según las características técnicas

Tapa transparente:
0 = versión standard
1 = con llave

Conexión eléctrica: con cable de 2 m de largo
A = 230 V, 50/60 Hz, enchufe plano
B = 230 V, 50/60 Hz, enchufe suizo
C = 230 V, 50/60 Hz, enchufe australiano
D = 115 V, 50/60 Hz, enchufe EE.UU.

Versión de control básica:
0 = versión básica*
1 = versión opcional
2 = versión opcional con iluminación del display digital
*Si se escoge la versión básica "0", todas las funciones opcionales especificadas a continuación deben ser también "0".

Tipo de control:
0 = manual + externo + pausa
1 = ídem 0 + c. analógico 0...20 mA, 4...20 mA
2 = ídem 0 + c. analógico 0-60 mV, 0-1 V, 0-10 V

Control de impulsos:
0 = sin control de impulsos
1 = con control de impulsos

Temporizador:
0 = sin temporizador
1 = con temporizador

Posibilidades de ajuste del relé:
0 = sin relé
1 = relé de alarma, vuelve a reposo en caso de alarma (normalmente cerrado)
2 = relé generador de impulsos, opera cuando se cierra
3 = relé de alarma, se cierra en caso de alarma*
4 = relé temporizador, opera cuando se cierra

*(normalmente abierto)

Ejemplo de un pedido

Se precisa una bomba dosificadora con una capacidad máx. de 1,8 l/h para dosificar, en función del caudal, silicato sódico concentrado en una tubería de agua potabel, a una contrapresión de 6 bar. La bomba se controlará a través de los contactos de un contador de agua ya existente, con un intervalo de impulsos excesivo, o bien a través de un caudalímetro magnético-inductivo (IDM), con una señal de 4-20 mA. En caso de fallos, se debe activar la correspondiente alarma en la central, y la bomba deba tener un sistema de seguridad para evitar que sea manipulada por personas no autorizadas. Será instalada en Francia.

El número de referencia de la gamma es el siguiente:

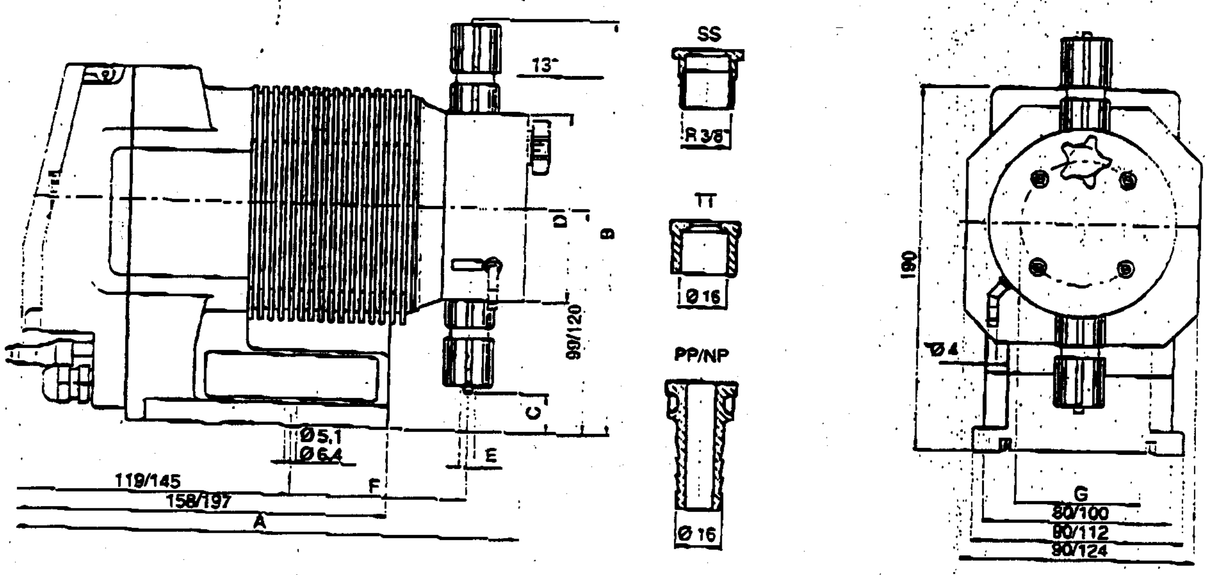
[redacted]	PP1	1	0	1	A	1	1	1	0	1

[redacted]	Serie
[redacted]	Presión máxima de 10 bar
[redacted]	Caudal máximo de 2,09 l/h
PP1	Resistencia del material (cabezal dosificador y juntas)
1	Con muelles en las válvulas, por tratarse de un líquido viscoso
0	Conexión standard 8 x 5 mm
1	Tapa con llave
A	230 V, 50-60 Hz enchufe plano
1	Versión opcional
1	Control analógico 4-20 mA
1	Con control de impulsos para la multiplicación de los impulsos
0	Sin temporizador
1	Relé de aviso de fallos, vuelve a reposo en caso de alarma

Dimensiones gamma/4, gamma/5

gamma/4		A	B	C	D	E	F	G
1000. 1601 1201	PP	232	186	17	70	6x4	81	38
	NP	230	179	19	70	6x4	81	38
	TT	213	173	25	60	6x4	79	38
	SS1	211	164	34	60	6x5	79	38
	SK1	211	162	36	60	1x8"	79	38
0703	PP	232	186	17	70	6x4	81	38
	NP	230	179	19	70	6x4	8.	38
	TT	213	178	20	70	6x4	79	38
	SS1	211	169	29	70	6x5	79	38
1002. 0308	PP	225	186	17	70	8x5	76	50
	NP	223	187	11	85	8x5	76	50
	TT	216	206	–8	80	8x5	79	50
	SS1	214	206	–8	80	8x7	77	50
0215	PP	225	197	6	90	12x9	76	66
	NP	223	195	3	100	12x9	76	66
	TT	216	214	–16	95	12x9	79	66
	SS1	214	209	–11	95	12x10	77	66
1002 HV	PP4	214	172	–4	70	DN 10	60	50
gamma/5								
1602 a 1006	PP	271	207	38	70	8x5	95	50
	NP	269	208	32	85	8x5	95	50
	TT	259	208	13	80	8x5	97	50
	SS1	259	220	20	80	8x7	97	50
(a): 1310 a 0613 (b): 0813 a 0417	PP	271	218	27	90	8x5/12x9	95	66
	NP	269	216	24	100	8x5/12x9	95	66
	TT	259	237	4	95	8x5/12x9	97	66
	SS1	259	230	11	95	8x7/12x10	97	66
0423 a 0230	PP	258	275	–18	135	DN 10-23x16	96	117
	NP	258	275	–18	135	DN 10-23x16	96	117
	TT	258	234	7	135	DN 10-d16	96	117
	SS1	258	234	7	135	DN 10-3/8"	96	117
1006 HV	PP4	269	193	47	85	DN 15	103	50
1310 HV	PP4	270	193	47	85	DN 15	104	66
0813 HV	PP4	269	200	40	100	DN 15	104	66

*Válvula de purga de aire y derivación sólo en los tipos 1000-0417 PP y NP
Dimensiones en mm



Características técnicas gamma/4, gamma/5

Tipo de bomba gamma		Caudal a contrapresión máxima bar	l/h	ml/impulsos	Caudal a contrapresión media bar	l/h	ml/impulsos	Frecuencia de impulsos impulsos/ min	Conexión* Ø ext. x Ø int. mm	Altura de aspiración mCA	Peso kg
gamma/4											
G/4a	1000	10	0,20	0,028	5	0,26	0.036	120	6 x 4	1,5	2,7- 3,4
	1601	16	0,90	0,125	8	1,17	0,16	120	6 x 4	6	2,7- 3,4
	1201	12	1,55	0,215	6	1,80	0,25	120	6 x 4	6	2,7- 3,4
	0703	7	3,40	0,47	3.5	3,67	0.51	120	6 x 4	3	2,7- 3,4
	1002	10	2,09	0,29	5	2,81	0,39	120	8 x 5	6	2,9- 4,1
	0308	3	7,78	1,08	1.5	8,5	1,18	120	8 x 5	6	2,9- 4,1
	0215	1.5	14.8	2.05	1	15.8	2.20	120	12 x 9	1,5	3,1- 4,7
gamma/5											
G/5a	1602	16	2.09	0,29	8	2,74	0.38	120	8 x 5	6	4,6- 5,8
	1605	16	4,74	0,79	8	5.76	0.96	100	8 x 5	6	6,7- 7,9
	1006	10	5,83	0,81	5	7,06	0,98	120	8 x 5	6	4,6- 5,8
	1310	13	9,54	1,59	6	10,8	1,8	100	8 x 5	6	6,9- 8,5
	0613	6	13,1	1,82	3	14.9	2.08	120	8 x 5	5,5	4,8- 6,4
	0813	8	13,3	2,21	4	14,6	2,44	100	12 x 9	6	6,9- 8,5
	0417	3.5	17,4	2,42	2	17.9	2.48	120	12 x 9	4,5	4,8- 6,4
	0423	3,5	22,5	3,75	2	24.6	4,10	100	DN 10	5	8,0-11,4
	0230	2	30,3	4,21	1	34,5	4,80	120	DN 10	2,5	5,9- 9,3
Bombas dosificadoras gamma "HV" para líquidos altamente visosos											
G/4a	1002	10	2,09	0,29	5	2.81	0.39	120	DN 10	–	3,2
G/5a	1006	10	5,83	0,81	5	7,06	0,98	120	DN 15	–	5,1
G/5a	1310	10	9,54	1,59	5	10,8	1,80	100	DN 15	–	7,4
G/5a	0813	8	13,3	2,21	4	14,6	2.44	100	DN 15	–	7,4

*versiones en acero inoxidable con rosca interior 6 x 5, 8 x 7, 12 x 10, DN 10-R 3/8"

Materiales empleados para los elementos en contacto con el líquido a dosificar:

	Cabezal dosificador	Conexión de aspiración/impulsión	Juntas	Bolas de las válvulas
PP1	polipropileno	polipropileno	EPDM	cerámica
PP2	polipropileno	polipropileno	Viton	cerámica
PP4*	polipropileno	polipropileno	EPDM	Duran
NP1	Plexiglas	PVC	Viton	cerámica
TT1	Teflón grafitado	Teflón grafitado	Teflón	cerámica
SS	acero inoxidable 1.4571	acero inoxidable 1.4571	Teflón	cerámica

*PP4 con muelles de Hast. C. en las válvulas
Membrana dosificadora DEVELOPAN® recubierta de Teflón

Plexiglas (NP), Viton (FKM) y Duran (vidrio de laboratorio) son marcas registradas.
La repetitividad de la dosificación es superior a ± 2% del valor ajustado, en caso de condiciones de servicio constantes y de instalación correcta, ajustando la longitud de la carrera en un valor entre el 30% y el 100%.
Temperatura ambiente admisible: –10 °C a +45 °C.
Potencia absorbida media a frecuencia máxima de impulsos (W)/Pico de corriente absorbid al efectuar un impulso (A):

G/4a	23 W/0.9 A	a máx. 120 imp./min.	– todos los tipos
G/5a	54 W/2.1 A	a máx. 120 imp./min.	– tipo 1602, 1006, 0613, 0417, 0230
G/5a	77 W/3,1 A	a máx. 100 imp./min.	– tipo 1605, 1310, 0813, 0423

Conexión eléctrica: 230 V ± 10%; 115 V ± 10%; 50/60 Hz. Margen de tolerancia: 195-265 V; 98-132 V.
Clase de protección IP 65; clase de aislamiento F.
Volumen de suministro: Bomba dosificadora con cable de red (2 m) y enchufe, juego de conexiones para conectar mangueras o tubos según lo indicado en la tabla.

Para informarse de las direcciones de los distribuidores, dirigirse al fabricante:

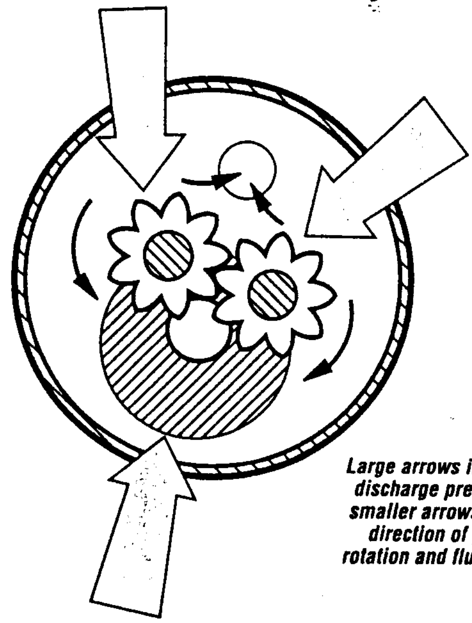
ProMinent Dosiertechnik GmbH
Im Schuhmachergewann 5-11
69123 Heidelberg
Postfach 10 17 60
69007 Heidelberg
Germany
Tel. + 49 (62 21) 8 42-0
Télex 46 16 97
Télefax + 49 (62 21) 8 42-419

PM-PT-257/8.93

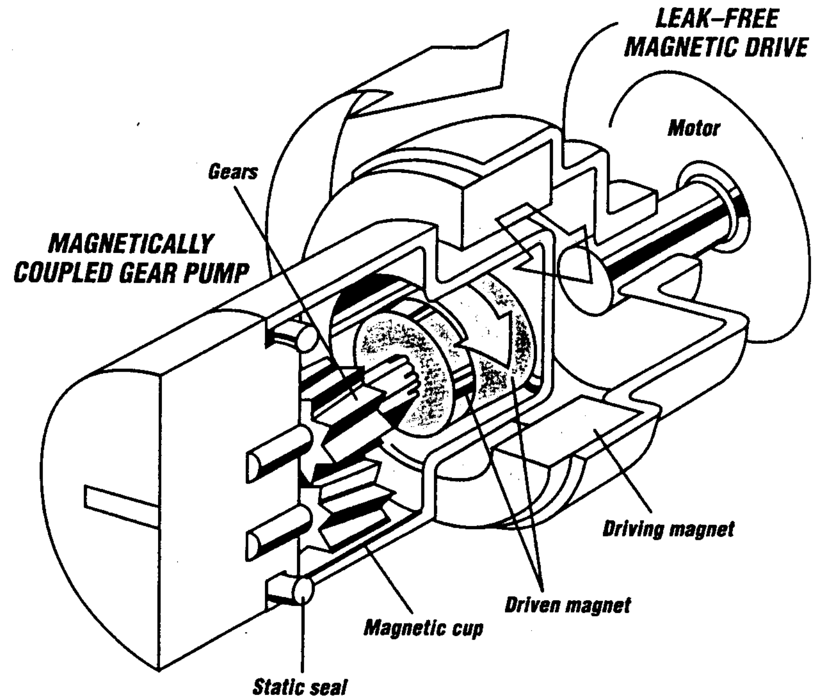
APPENDIX 3

MICROPUMP® PUMP TECHNOLOGY

The following introduction explains the basic technology behind magnetically coupled gear pumps and helps you to differentiate between the two types of MICROPUMP® pump heads offered—conventional cavity-style and pressure-loaded.



Large arrows indicate discharge pressure; smaller arrows show direction of gear rotation and fluid flow.



Magnetically coupled gear pumps are designed for pulseless fluid delivery at low to moderate flow rate and pressure. They operate via two or three rotating gears. One of the gears is turned by a power source (via magnetic coupling) and drives the other gear(s). The spaces between the gear teeth carry the fluid from the inlet to the outlet as shown above.

Gear pumps can pass air bubbles and still maintain their prime. Some gear pumps can attain maximum pressure with practically no loss in flow.

Magnetically coupled gear pumps eliminate shaft seals—ensure freedom from leaks and contamination. The conventional means of sealing pumps is by using some type of dynamic seal (i.e., a seal created on a movin(shaft) which allows possible areas for leakage, creates additional friction for the motor to overcome, and often generates heat

HOW TO CHOOSE YOUR PUMP HEAD AND MOTOR

We offer this high-quality line of pump heads and motors as separate components to let you create a pumping system that meets your specific requirements. To help determine the best combination of pump head and motor for you needs, consider the following factors.

FLUID CHARACTERISTICS—Consider the chemical compatibility, viscosity, and temperature of the fluid. Determine also whether the fluid is shear sensitive, is sensitive to particles shed from gear wear, or contains particles. Gear pumps are not well suited for shear-sensitive fluids or fluids which are sensitive to particles from gear wear. Gear pumps are particularly well suited for viscous fluids up to 1500 centipoise.

SYSTEM CHARACTERISTICS—Consider your desired flow rate, differential pressure, and system pressure. MICROPUMP® pump heads handle flow rates up to 68 LPM (18 GPM), differential pressures up to 100 psi, and system pressures up to 1500 psi.

Determine whether the inlet will be flooded, pressurized, or requiring a suction lift. If the inlet is flooded, use either a conventional cavity-style or a pressure-loaded pump head. If the inlet is pressurized or a suction lift is needed, use a cavity-style pump head. If the initial differential pressure will be high, use a pressure-loaded pump head.

Choose a pump head without a canister, with standard or large canisters, or with NEMA Type 56 C-face flange adapters according to your required motor mounting configuration.

MAINTENANCE REQUIREMENTS—Depending on your application, your pump maintenance may simply include such routine procedures as the occasional replacement of gears and bearings on pump heads or the replacement of brushes on brushed motors. Or you may need to sterilize the pump head between runs or between successive applications.

Cavity-style pump heads with Teflon®, Ryton® or graphite gears can be autoclaved intact or after disassembly (do not exceed 250°F temperatures for the Teflon and Ryton gears). Use only chemicals to sterilize pressure-loaded pump heads with Ryton gears.

DRIVE REQUIREMENTS—Consider the motor and control requirements of your application. The MICROPUMP system lets you use an AC, DC, or pneumatically driven motor; a continuous- or intermittent-duty motor; or a fixed- or variable-speed motor with manual or external controls. Cole-Parmer offers a wide selection of drives from simple fixed-speed AC motors to variable-speed drives with digital display, timer, and remote control or computer interface capability. We also have adapters for NEMA Type 56 C-face motors and IEC/ISO 63 or 71 frame metric motors.

CAVITY-STYLE PUMP HEADS

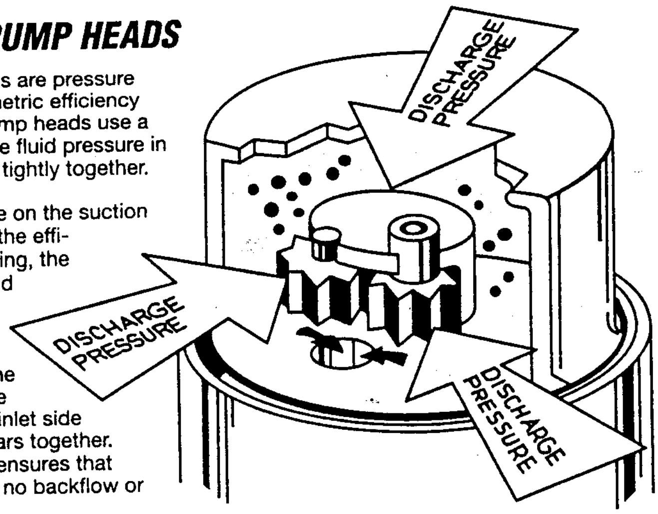
Series A, B, E, and F pump heads use conventional cavity-style gear technology. These cavity-style pump heads feature suction lift capabilities, are easier to clean and service, and are less expensive than the pressure-loaded type.

Cavity-style gear pumps do not use a suction shoe but depend on the surrounding pressure in the magnet cup cavity to hold the gears tightly together. Since it is imperative that the gear tips mesh exactly, cavity-style pump heads often use helical gears composed of extremely low friction material—such as Teflon®.

PRESSURE-LOADED PUMP HEADS

Series C, D, G, and H pump heads are pressure loaded, thus increasing the volumetric efficiency of the pump. Pressure-loaded pump heads use a suction shoe which works with the fluid pressure in the magnet cup to seal the gears tightly together.

The higher the discharge pressure on the suction shoe and mesh point, the higher the efficiency of the pump. While operating, the magnetic cup is filled with the fluid being pumped. The suction shoe is positioned around the inlet and meshing point (see diagram at right). The pressure on the outlet side of the pump should be greater than the pressure on the inlet side to force the suction shoe and gears together. In this manner, the suction shoe ensures that fluid transport is complete—with no backflow or leakage between gear tips.



MICROPUMP® PUMP HEAD AND MOTOR COMPATIBILITY GUIDE

Use the following charts to compare the maximum flow rates that are achievable with various motor and MICROPUMP® pump head combinations. Maximum flow rates (given in ml/min) were determined under conditions of nominal back pressure.

For a complete description of each motor, see the "Motors" section on pages 741-745. For details on pump heads, see pages 1130-1132.

MOTORS FOR MICROPUMP® PUMP HEADS WITHOUT CANISTER (SERIES A AND C)

Motor model number	Max motor speed (rpm)	Maximum flow rate (ml/min) using indicated pump head model at given speed*				
		Series A cavity-style	Series C pressure-loaded			
		07002-20	07002-32	07002-33	07002-35	07002-12
07002-39	500	N/R	8.5	20	40	N/R
07002-42	6000	1920	N/R	N/R	N/R	N/R
07002-38	8000	N/R	135	335	670	740

*N/R = not recommended for use with indicated motor.

MOTORS FOR MICROPUMP® PUMP HEADS WITH STANDARD CANISTER (SERIES B AND D)

Motor model number	Max motor speed (rpm)	Maximum flow rate (ml/min) using indicated pump head model at given speed*											
		Series B cavity-style						Series D pressure-loaded					
		07002-16	07002-17	07002-23	07001-80	07001-70	07001-40	07002-25	07002-26	07002-27	07002-14	07003-02	07003-04
07002-58	1550	495	495	990	990	1040	1460	25	65	130	145	870	1690
07144-93, -94	3000	960	960	1920	1920	2000	2800	50	125	250	275	1690	3300
07144-95, 07003-83	3150	1010	1010	2000	2000	2100	3000	55	130	265	290	1780	3400
07144-00, -02, 07144-05, -07, 75210-00, -05, 75210-10, -15	3600	1150	1150	2300	2300	2400	3400	60	150	300	330	2000	3900
07003-90, 78200-22, 78200-27, 07144-91	4000	1280	1280	2600	2600	2700	3800	70	170	335	370	2300	4400
07617-60, -62, 07617-75, -77	5000	1600	1600	3200	3200	3300	4700	85	210	420	460	N/R	N/R
07617-70, -72 78004-00	6100	1950	1950	3900	3900	4100	5700	105	255	510	560	3400	6600
07144-97	8000	2600	2600	5100	5100	5400	7500	135	335	670	735	4500	8700
07002-44, -45, 07002-46, -47	9000	2900	2900	5800	5800	N/R	N/R	N/R	N/R	760	830	N/R	9800

*N/R = not recommended for use with indicated motor.

MOTORS FOR MICROPUMP® PUMP HEADS WITH LARGE CANISTER (SERIES E AND G)

Motor model number	Max motor speed (rpm)	Maximum flow rate (ml/min) using indicated pump head model at given speed*				
		Series E cavity-style	Series G pressure-loaded			
		07001-52	07003-06	07003-08	07003-30	07003-31
07003-36	3150	9000	N/R	5000	N/R	N/R
07003-37 07002-49	3200	9200	2700	5100	5500	11,100
07002-51	3400	9700	2900	N/R	N/R	11,800
07003-82	4300	N/R	N/R	N/R	7400	N/R

*N/R = not recommended for use with indicated motor.

NEMA TYPE 56 C-FACE MOTORS FOR MICROPUMP® PUMP HEADS WITH NEMA TYPE 56 C-FACE FLANGE ADAPTER (SERIES F AND H)

Max motor speed (rpm)	Maximum flow rate (ml/min) using indicated pump head model with any NEMA Type 56C-face motor at given speed						
	Series F cavity-style			Series H pressure-loaded			
	07001-54	07003-25	07003-27	07003-34	07003-35	07003-32	07003-33
1725	4900	10,400	33,300	1500	2800	3000	6000
3450	9900	20,700	66,600	2900	5500	6000	11,900

MICROPUMP—Reg TM Micropump Corp.
Ryton—Reg TM Phillips Petroleum Co.
Teflon—Reg TM E. I. du Pont de Nemours & Co.

MICROPUMP® PUMP HEADS

- Easily interchangeable on various motors
- Pulse-free flow
- Teflon® PTFE, Ryton®, or graphite gears

These MICROPUMP® pump heads feature an enclosed gear assembly designed for smooth, quiet operation. Driven magnets are encapsulated in 316 stainless steel (SS) and either Teflon® PTFE or Ryton® for good durability and chemical resistance. All-plastic PVDF and Teflon® PTFE pump heads are available—call for details.

Use series A through D (on pages 1130-1131) for your low-flow general-purpose applications—up to 7500 ml/min. Models with an internal bypass valve recirculate excess discharge pressure to the inlet side of the pump to protect the pump head and entire system from excessive pressures. Use series E through H (on page 1132) for your high-capacity applications—up to 38.6 liters/min.

Use the flow performance graphs on pages 1130-1132 for guidance in choosing the best pump head for your application. The graphs and tables are color-coded according to materials of construction; refer to the pump head ordering tables for the specific materials. See page 1129 for the maximum flow rates of specific pump head and motor combinations.

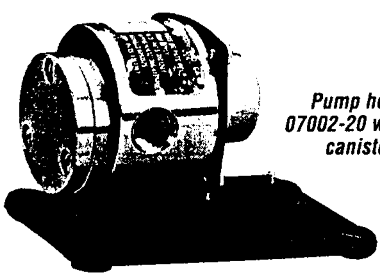
MICROPUMP pump heads feature a ⅛" NPT(F) port size and are interchangeable to satisfy a variety of flow rate, pressure, and fluid compatibility requirements. All of these pump heads can be used with the motors identified on page 1129.

Optional service kits contain gears, bushings, seals, and suction shoe (for pressure-loaded pump heads); order kits separately from pump head ordering tables.

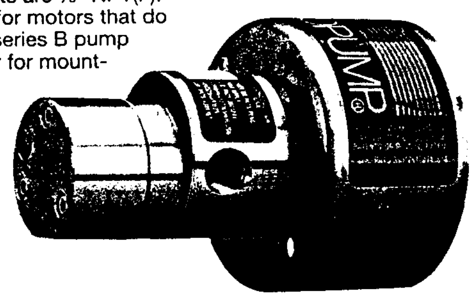
MICROPUMP—Reg TM Micropump Corp. **Ryton**—Reg TM Phillips Petroleum Co. **Teflon, Viton**—Reg TM E. I. du Pont de Nemours & Co.

CAVITY-STYLE PUMP HEADS

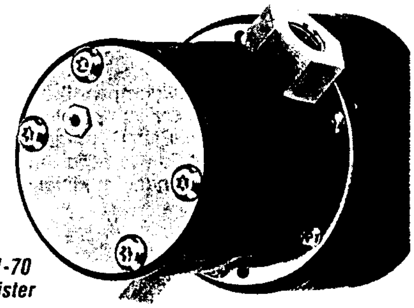
These conventional cavity-style pump heads provide nominal flow rates from 1100 to 3200 ml/min (see table below). Ports are ⅛" NPT(F). Choose series A pump head (model 07002-20) for motors that do not require a canister for mounting. Select any series B pump head for motors that require a standard canister for mounting. Series B pump heads are available with an internal bypass valve.



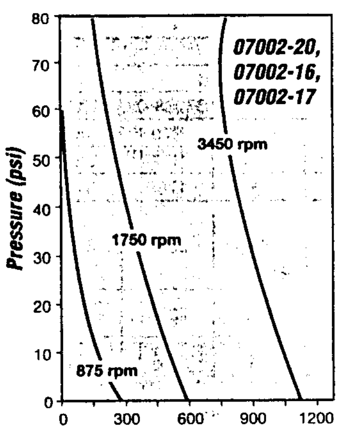
Pump head 07002-20 without canister

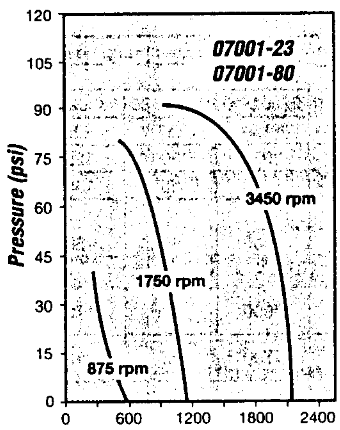


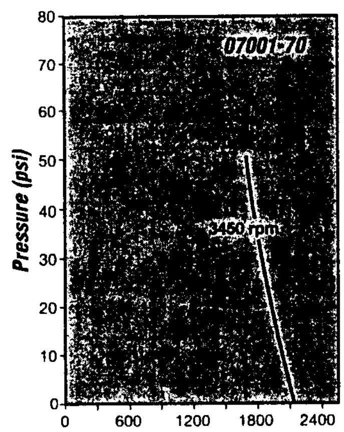
Pump head 07002-23 with internal bypass valve

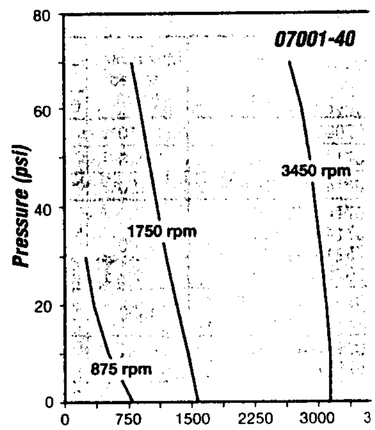


Pump head 07001-70 with standard canister









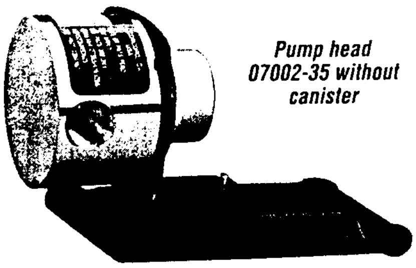
Series	Catalog number	ml/rev	Nominal flow rate (ml/min)*	Max system psi	Max diff psi	Materials of construction: Body	Gears	Seals	Max rpm	Temperature range	Bypass valve	Price	Service kits: Catalog number	Price
Cavity-style pump heads without canister														
A	**H-07002-20**	0.32	1100	300	45	316 SS	Teflon PTFE	Teflon PTFE	9000	–50 to 130°F†	No	**$405.00**	**H-07002-10**	**$136.00**
Cavity-style pump heads with standard canister														
B	**H-07002-16**	0.32	1100	300	45	316 SS	Teflon PTFE	Teflon PTFE	9000	–50 to 130°F†	No	**405.00**	**H-07144-38**	**136.00**
B	**H-07002-17**	0.32	1100	300	45	316 SS	Teflon PTFE	Teflon PTFE	9000	–50 to 130°F†	Yes	**405.00**	**H-07144-38**	**136.00**
B	**H-07002-23**	0.64	2200	300	45	316 SS	Teflon PTFE	Teflon PTFE	9000	–50 to 130°F†	Yes	**373.00**	**H-07002-08**	**84.50**
B	**H-07001-80**	0.64	2200	300	45	316 SS	Ryton	Teflon PTFE	9000	–50 to 250°F	Yes	**373.00**	**H-07001-89**	**84.50**
B	**H-07001-70**	0.67	2310	200	45	Ryton/316 SS	Ryton	Viton	9000	–50 to 150°F	Yes	**267.00**	—	—
B	**H-07001-40**	0.94	3240	300	45	316 SS	Teflon PTFE	Teflon PTFE	8000	–50 to 210°F	Yes	**373.00**	**H-07001-41**	**84.50**

*Nominal flow rate pumping water with no back pressure at 3450 rpm. †Up to 210°F using the high-temperature seals below.

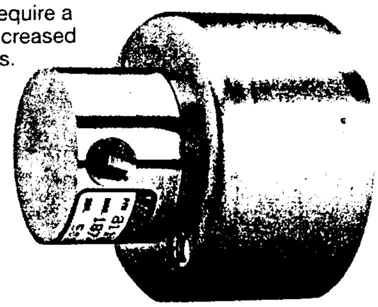
H-07002-05 High-temperature Teflon FEP seals let you use pump heads 07002-16, -17, -20, and -23 (this page) and 07002-12, -25, -26, and -27 (facing page) at temperatures up to 210°F. Pack of two seals...$5.90/p

PRESSURE-LOADED PUMP HEADS

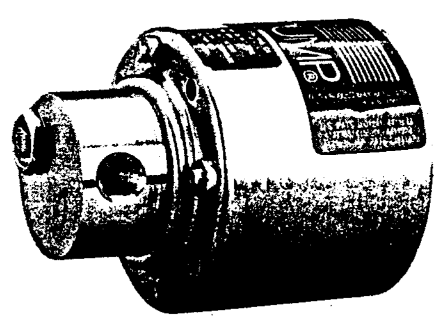
These pressure-loaded pump heads provide nominal flow rates from 60 to 3800 ml/min (see table below). Ports are ⅛" NPT(F). Select series C pump heads for motors that do not require a canister for mounting. Choose series D pump heads for motors that require a standard canister for mounting. All models give you the increased volumetric efficiency common to pressure-loaded systems.



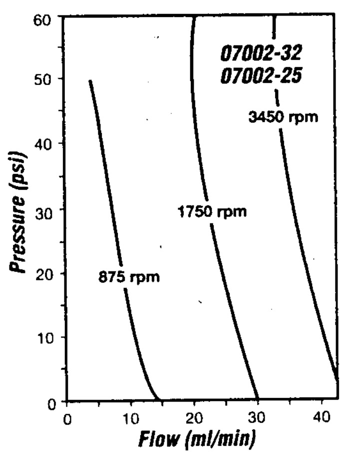
Pump head 07002-35 without canister

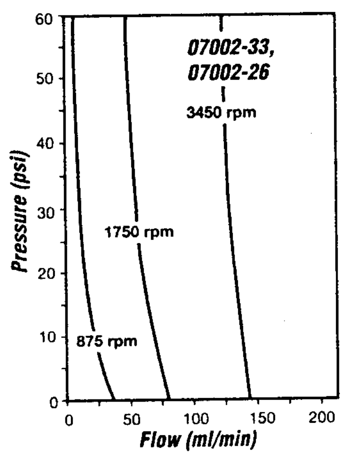


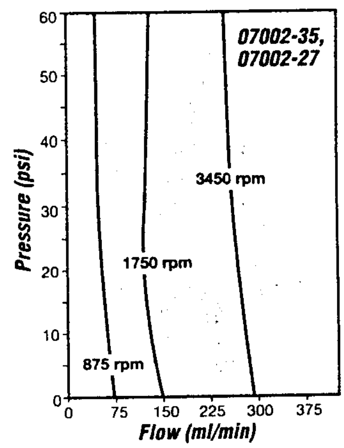
Pump head 07002-25 with standard canister

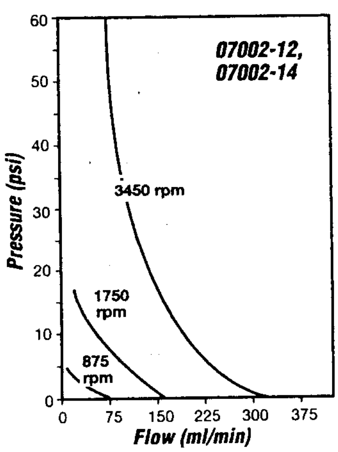


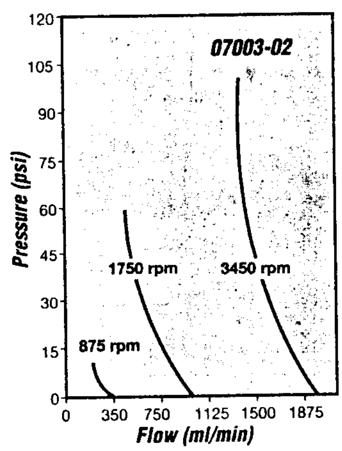
Pump head 07003-02 with standard canister and internal bypass valve

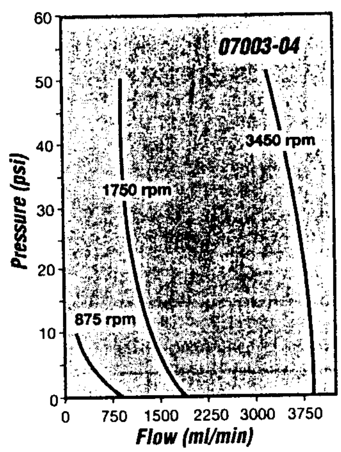












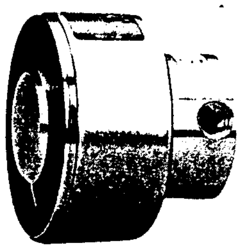
Series	Catalog number	ml/rev	Nominal flow rate (ml/min)*	Max system psi	Max diff psi	Materials of construction: Body	Materials of construction: Gears	Materials of construction: Seals	Max rpm	Temperature range	Bypass valve	Price	Service kits: Catalog number	Service kits: Price
Pressure-loaded pump heads without canister														
C	H-07002-32	0.017	55	300	50	316 SS	Graphite	Teflon PTFE	8000	–50 to 250°F	No	$419.00	H-07144-42	$141.00
C	H-07002-33	0.042	140	300	50	316 SS	Graphite	Teflon PTFE	8000	–50 to 250°F	No	419.00	H-07144-44	141.00
C	H-07002-35	0.084	290	300	60	316 SS	Graphite	Teflon PTFE	8000	–50 to 250°F	No	419.00	H-07144-47	141.00
C	H-07002-12	0.092	310	300	50	316 SS	Ryton	Teflon PTFE	9000	–50 to 130°F†	No	419.00	H-07144-36	141.00
Pressure-loaded pump heads with standard canister														
D	H-07002-25	0.017	55	300	50	316 SS	Graphite	Teflon PTFE	9000	–50 to 250°F	No	419.00	H-07144-42	141.00
D	H-07002-26	0.042	140	300	50	316 SS	Graphite	Teflon PTFE	9000	–50 to 250°F	Yes	419.00	H-07144-44	141.00
D	H-07002-27	0.084	290	300	50	316 SS	Graphite	Teflon PTFE	9000	–50 to 250°F	Yes	419.00	H-07144-47	141.00
D	H-07002-14	0.092	310	300	50	316 SS	Ryton	Teflon PTFE	9000	–50 to 210°F	Yes	419.00	H-07144-34	141.00
D	H-07003-02	0.564	1940	300	50	316 SS	Ryton	Viton	8000	–50 to 210°F	Yes	392.00	H-07003-12	101.00
D	H-07003-04	1.090	3760	300	45	316 SS	Ryton	Viton	9000	–50 to 250°F	Yes	392.00	H-07003-14	101.00

*Nominal flow rate pumping water with no back pressure at 3450 rpm. †Up to 210°F using the high-temperature seals on facing page.

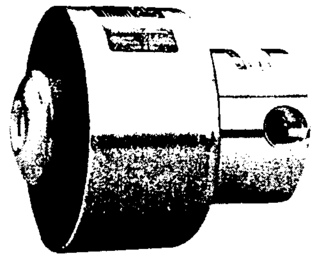
MICROPUMP® PUMP HEADS (continued from page 1131)

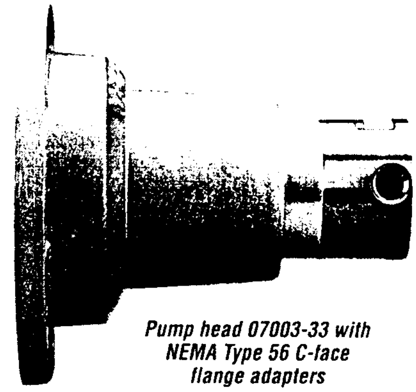
We offer these high-capacity MICROPUMP® pump heads in conventional cavity-style and pressure-loaded types. Both types are available with large canisters or with NEMA Type 56 C-face flange adapters. Order a pump head according to your required mounting configuration.

Pump head 07003-08 with large canister

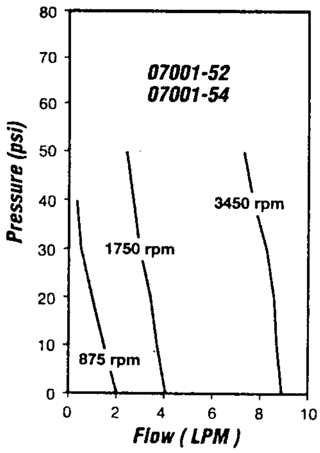


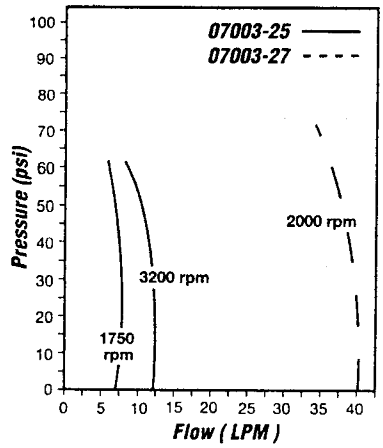
Pump head 07003-30 with large canister

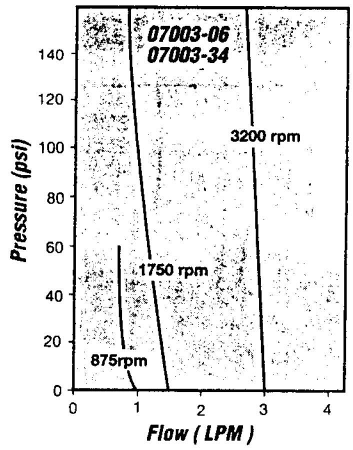


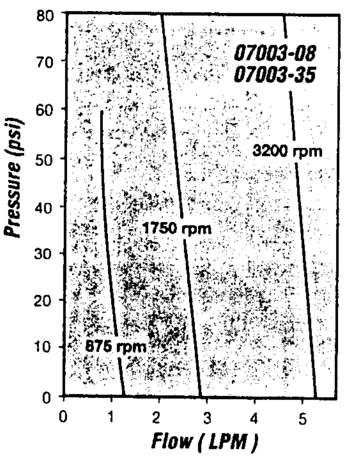


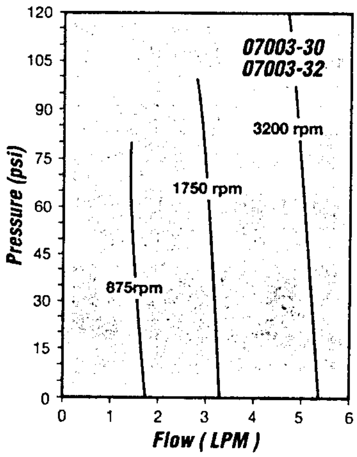
Pump head 07003-33 with NEMA Type 56 C-face flange adapters

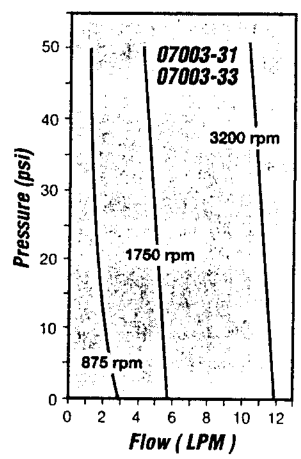












Series	Catalog number	ml/rev	Nominal flow rate (liters/min)*	Max system psi	Max diff psi	Materials of construction			Max rpm	Temperature range	Bypass valve	Price	Service kits	
						Body	Gears	Seals					Catalog number	Price
Cavity-style pump heads with large canister														
E	H-07001-52	2.86	9.8	300	45	316 SS	Teflon® PTFE	Teflon PTFE	3450	32 to 125°F	No	$1520.00	H-07001-55	$357.00
Cavity-style pump heads with NEMA Type 56 C-face flange adapter														
F	H-07001-54	2.86	9.8	300	45	316 SS	Teflon PTFE	Teflon PTFE	3450	32 to 125°F	No	1710.00	H-07001-55	357.00
F	H-07003-25	6.00	20.8	500	70	316 SS	Teflon PTFE	Teflon PTFE	4000	–50 to 210°F	No	2400.00	H-07003-26	627.00
F	H-07003-27	19.30	38.6	500	100	316 SS	Teflon PTFE	Teflon PTFE	4000	–50 to 210°F	No	4450.00	—	—
Pressure-loaded pump heads with large canister														
G	H-07003-06	0.85	3.0	1500	60	316 SS	Ryton®	Viton®	8000	–50 to 250°F	No	816.00	H-07003-16	114.00
G	H-07003-08	1.60	5.2	1500	60	316 SS	Ryton	Viton	6000	–50 to 250°F	No	816.00	H-07003-18	114.00
G	H-07003-30	1.73	6.0	1000	50	316 SS	Ryton	Viton	6000	–50 to 250°F	No	855.00	H-07003-38	114.00
G	H-07003-31	3.46	12.3	1000	50	316 SS	Ryton	Viton	4000	–50 to 250°F	No	855.00	H-07003-39	114.00
Pressure-loaded pump heads with NEMA Type 56 C-face flange adapter														
H	H-07003-34	0.85	3.0	1500	60	316 SS	Ryton	Viton	8000	–50 to 250°F	No	1050.00	H-07003-17	114.00
H	H-07003-35	1.60	5.2	1500	60	316 SS	Ryton	Viton	6000	–50 to 250°F	No	1050.00	H-07003-19	114.00
H	H-07003-32	1.73	6.0	1000	50	316 SS	Ryton	Viton	6000	–50 to 250°F	No	1080.00	H-07003-38	114.00
H	H-07003-33	3.46	12.3	1000	50	316 SS	Ryton	Viton	4000	–50 to 250°F	No	1080.00	H-07003-39	114.00

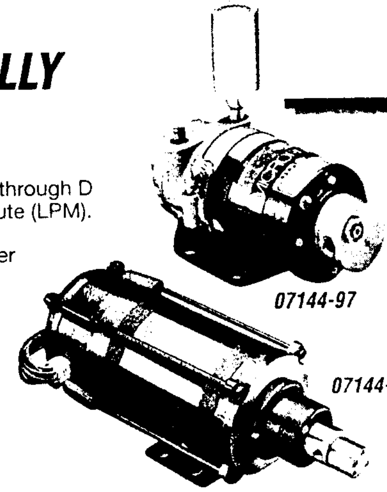
*Nominal flow at 3450 rpm pumping water with no back pressure.

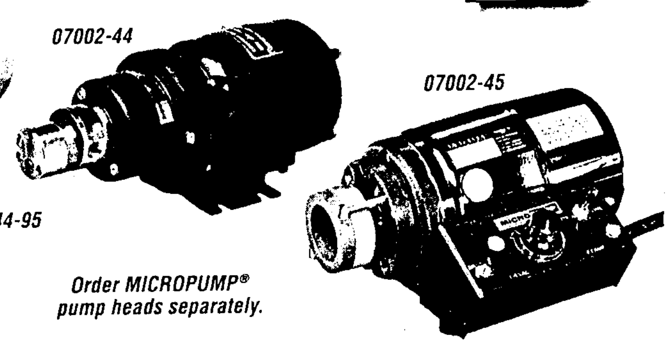
STANDARD MAGNETICALLY COUPLED MOTORS

Use these motors with MICROPUMP® series A through D pump heads for flow rates up to 8.72 liters/minute (LPM).

Magnetic seal minimizes friction—all horsepower is transmitted directly to the motor gears. The result is hundreds of hours of dependable, leakproof service.

Use the flow capacity values (see page 1129 for series A and C; see second table below for series B and D) to determine the best combination of motor and MICROPUMP pump head for your pumping needs.





Order MICROPUMP® pump heads separately.

MOTOR SPECIFICATIONS AND ORDERING INFORMATION

Catalog number	Type	rpm	Frame	Motor	hp	Power source	Termination	Dimensions L x W x H	Shpg wt lbs (kg)	Price
Motors for use with MICROPUMP pump heads without canister (series A and C). See page 1129 for maximum flow capacities.										
H-07002-39	DC	500	TENV	PM brush	0.005	0 to 24 VDC, 0.60 A	Alligator clip	4" x 1½" x 1¾"	1 (0.5)	$235.00
H-07002-42	DC	6000	TENV	PM brush	0.015	0 to 12 VDC, 2.50 A	Alligator clip	3¼" x 1½" x 1½"	1 (0.5)	172.00
H-07002-38	DC	8000	TENV	PM brush	0.01	0 to 24 VDC, 0.50 A	Alligator clip	3¼" x 1½" x 1½"	1 (0.5)	197.00
Motors for use with MICROPUMP pump heads with standard canister (series B and D). See flow capacities table below.										
H-07144-91	DC	4000	TENV	PM brush	0.12	0 to 12 VDC, 4 A	13" wire leads	4" x 3" x 3"	3 (1.4)	158.00
H-07003-90	DC	4000	TENV	PM brush	0.12	0 to 24 VDC, 3 A	13" wire leads	4" x 3" x 3"	3 (1.4)	158.00
H-07002-58	AC	1550	TEFC	Shaded pole	0.05	115/230 VAC, 50/60 Hz, 1.5 A	12" wire leads	5¼" x 4 x 4¼"	6 (2.7)	223.00
H-07144-93	AC	3000	TEFC	Shaded pole	0.05	115 VAC, 50/60 Hz, 1.9 A	6-ft cord & plug	5¼" x 4 x 4¼"	7 (3.2)	223.00
H-07144-94	AC	3000	TEFC	PSC	0.1	115/230 VAC, 50/60 Hz, 1.4 A	19" wire leads	6" x 5¼" x 5"	7 (3.2)	294.00
H-07002-44	AC/DC*	9000	Open	Brush	0.123	115 VAC, 50/60 Hz, 2.1 A	6-ft cord & plug	5½" x 3¼" x 4"	5 (2.3)	261.00
H-07002-45	AC/DC, v-spd*	9000	Open	Brush	0.123	115 VAC, 50/60 Hz, 2.1 A	8-ft cord & plug	5½" x 5 x 3¼"	6 (2.7)	361.00
H-07002-46	AC/DC*	9000	Open	Brush	0.123	230 VAC, 50/60 Hz, 1.1 A	6-ft cord	5½" x 3¼" x 4"	5 (2.3)	361.00
H-07002-47	AC/DC, v-spd*	9000	Open	Brush	0.123	230 VAC, 50/60 Hz, 1.1 A	6-ft cord	5½" x 5" x 3¼"	6 (2.7)	361.00
H-07144-95	XPRF†	3150	NEMA 42	PSC	0.17	115/230 VAC, 50/60 Hz, 1.8 A	6" wire leads	11" x 6" x 5¼"	20 (9.1)	634.00
H-07144-97	Air driven	8000	TENV	Vane	0.13 to 0.29	5 to 11 SCFM; 5 to 80 psi	⅛" NPT(F)	3¾" x 3" x 5¼"	3 (1.4)	311.00

*For intermittent use only. †Rated for NEMA Class I, Groups C and D, Division 1 hazardous environments.

FLOW CAPACITIES FOR MICROPUMP® PUMP HEADS WITH STANDARD CANISTER

Pump heads			Flow rates (liters/min) using indicated pump motors					
Series	Model number(s)	ml/rev	07002-58 1550 rpm	07144-93, -94 3000 rpm	07144-95 3150 rpm	07003-90, 07144-91 4000 rpm	07144-97** 8000 rpm	07002-44, -45, -46, -47 9000 rpm
D	07002-25	0.017	0.026	0.051	0.054	0.068	0.136	—
D	07002-26	0.042	0.065	0.126	0.132	0.168	0.336	—
D	07002-27	0.084	0.130	0.252	0.265	0.336	0.672	—
D	07002-14	0.092	0.143	0.276	0.290	0.368	0.736	0.828
B	07002-16, -17	0.316	0.490	0.948	0.995	1.26	2.53	2.84
D	07003-02	0.564	0.874	1.69[1]	1.78	2.26	4.51	5.08[1]
B	07002-23	0.640	0.992	1.92	2.02	2.56	5.12	5.76[1]
B	07001-80	0.640	0.992	1.92	2.02	2.56	5.12	5.76[1]
B	07001-70	0.670	1.04	2.01	2.11	2.68	5.36	6.03
B	07001-40	0.94	1.46	2.82	2.96	3.76	7.52	—
D	07003-04	1.090	1.69	3.27[1]	3.43	4.36	8.72	—

[1]Specifications may be lower for these pump head/motor combinations if used above maximum continuous-duty pressures. **At 20 psi motor inlet. MICROPUMP—Reg TM Micropump Corp.

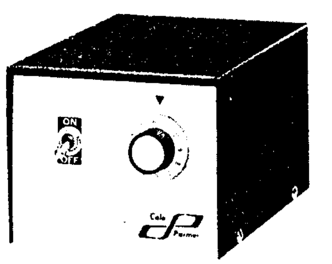
POWER SUPPLIES/SPEED CONTROLLERS

- *Provide DC output for small motors, metering pumps, and more*

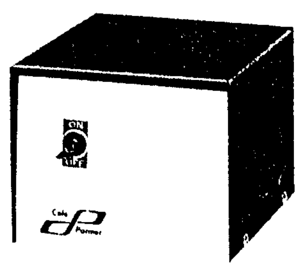
These compact controllers rectify 115 VAC to either 12 VDC (models 02630-25 and -90) or 20 VDC (models 02630-85, -95, and -87). Manual models provide a constant, preselected VDC output. Automatic models respond to standard analog inputs (1-5 mA, 4-20 mA, 0-5 V) from control instruments. Output voltage adjusts continuously, proportional to input signal.

Automatic models feature offset and span adjustments and IR compensation. Offset and span adjustments let you adjust VDC output to any input range. IR compensation increases amperage output to maintain constant speeds under increasing loads.

Units measure just 7¾"L x 5½"W x 4 3/16"H. All models come with a 6-ft, three-wire, UL-listed cord with plug and a 2-amp fuse. Because the primary side of the transformer is fused, both primary and secondary circuits are protected.



Manual controller



Automatic controller

Catalog number	Type	Output	Shpg wt lbs (kg)	Price
H-02630-25	Manual	1 to 12 VDC, 7 amps	6 (2.7)	$235.00
H-02630-90	Automatic	1 to 12 VDC, 7 amps	6 (2.7)	359.00
H-02630-85	Manual	2 to 20 VDC, 3.5 amps	7 (3.2)	235.00
H-02630-95	Automatic	2 to 20 VDC, 3.5 amps	6 (2.7)	359.00
H-02630-87	Manual	2 to 20 VDC, 7 amps	9 (4.1)	294.00

COLE-PARMER® VARIABLE-SPEED DRIVES

Use these continuous-duty drives with MICROPUMP® pump heads with standard canister (series B and D sold on facing page); get flow rates up to 3900 ml/min. Drives feature a 1⁄10 hp DC motor with high-torque magnetic coupler and mounting adapter. Speed control is adjustable from 180 to 3600 rpm via single-turn potentiometer. Maximum differential pressure is 50 psi. Soft-start feature allows gradual one-second acceleration to any chosen speed for smooth, pulseless flow rate changes.

MOTOR/CONTROLLER SYSTEM

07144-05

System comes complete with controller connected to a motor via a 6-ft cable. Controller features exceptional line/load regulation of ±2% and improved regulation of motor current, which minimizes magnetic drive decoupling. Solid-state controller is UL-listed under UL508, is CSA-certified, and has an IP53 rating. Controller measures 7"W x 3¼"H x 5¼"D.

Motor includes a welded base for mounted or for free-standing use. Motor has an IP21 rating; comes with a 6-ft power cord with U.S. standard plug on 115 VAC model (European plug on 230 VAC model; other plug types available on request). Motor measures 6¹³⁄₁₆"L x 4¹³⁄₁₆"W x 3⅝"H.

H-07144-05 Continuous-duty motor/controller system; 115 VAC, 50/60 Hz. Shpg wt 9 lbs (4.1 kg) $600.00
H-07144-07 Continuous-duty motor/controller system; 220 VAC, 50/60 Hz. Shpg wt 9 lbs (4.1 kg) $600.00
H-07144-08 Replacement controller for model 07144-05. Shpg wt 3 lbs (1.4 kg) $241.00
H-07144-09 Replacement controller for model 07144-07. Shpg wt 3 lbs (1.4 kg) $241.00

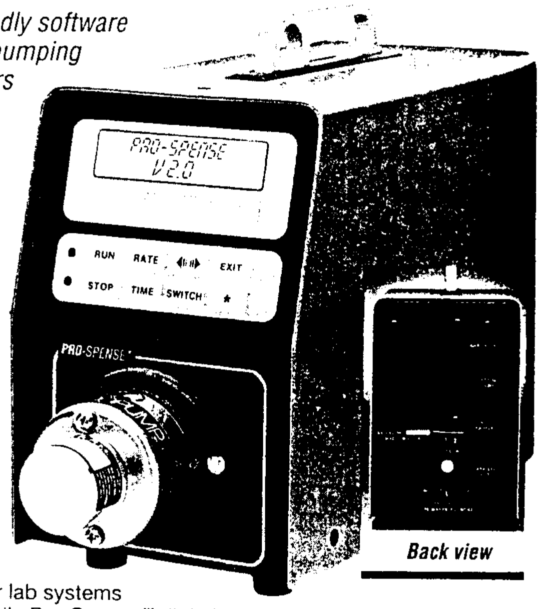
CONSOLE DRIVE

Motor and controller are enclosed in a case that has carrying handle and feet. Adjust speed using the front-panel potentiometer or by remote control—a ¼" phone jack port accepts a 4-20 mA input signal. Remote control linearity is better than ±3% FS. Both models include 6-ft power cord; 115 VAC model includes plug. Units have an IP22 rating and measure 11⁷⁄₁₆"L x 6⁷⁄₁₆"W x 5⁷⁄₁₆"H. Shpg wt 10 lbs (4.5 kg).

H-07144-00 Console drive; 115 VAC, 50/60 Hz. $676.00
H-07144-02 Console drive; 230 VAC, 50/60 Hz. $676.00

PRO-SPENSE™ DIGITAL PUMP/CONTROLLER

User-friendly software controls pumping parameters



Back view

Automate your lab systems with our versatile Pro-Spense™ digital pump/controller. Controller can be used with the MICROPUMP pump heads with standard canister (series B and D sold on facing page). Built-in software lets you use controllers to operate pumps, motors, relays, and other devices as you dispense. Convenient LCD keeps you constantly informed of operating conditions. A serial output lets you daisy chain controllers for a number of applications. Connect to analog devices such as pH or flow controllers for precise liquid batch dispensing, or top-loading balances for gravimetric batching or dispensing.

Controller allows you to pump fluids at flow rates up to 4400 ml/min. Max differential pressure is 50 psi; max temperature is 250°F (121°C). Motor speed range is 0-4000 rpm. Measures 5½" W x 8½"H x 10"D.

Interface controller with an IBM®-compatible personal computer to download stored programs at any time. Your computer keyboard can also serve as a central control for all pump functions. IBM-compatible software program (included) confirms that proper RS-232 serial connection to your computer has been established. Order connecting cables from the table below.

H-78200-22 Pump/controller; 120 VAC, 60 Hz. Shpg wt 10 lbs (4.5 kg) $2120.00
H-78200-27 Pump/controller; 240 VAC, 50 Hz. Shpg wt 10 lbs (4.5 kg) $2120.00

CONNECTING CABLES

Cat. no.	Function	Length	Price
Personal computer and balance cables; DB9 female connector			
H-78200-50	Interface 1 pump to a computer	5 ft	$ 75.50
H-78200-52	Daisy chain 2 pumps to a computer	5 ft	118.00
H-78200-70	Interface with an Ohaus® balance	6 ft	59.00
H-78200-72	Interface with a Sartorius balance	6 ft	116.00
H-78200-74	Interface with a Mettler balance	6 ft	141.00
I/O and master/slave cables; DB37 male connector			
H-78200-62	Synchronize 2 pumps; ⅛" mini jack	6 ft	65.00
H-78200-64	Synchronize 3 pumps; two ⅛" mini jacks	6 ft	100.00
H-78200-66	Interface up to 3 analog units; 3 pigtail leads	9 ft	65.00
H-78200-68	Access up to 4 TTL switches; 4 pigtail leads	9 ft	59.00
Autosampler cable; DB15 male connector			
H-78200-54	Interface controller with an autosampler	5 ft	75.50

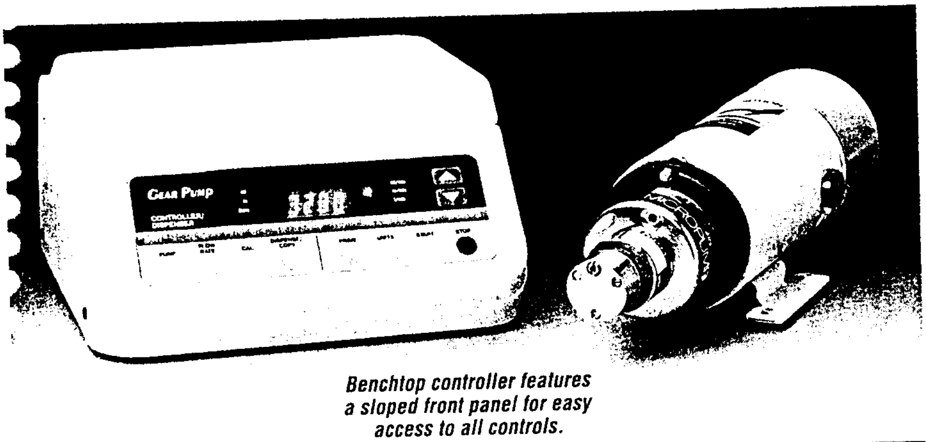
ACCESSORIES (for Pro-Spense pump/controllers)

H-78200-58 I/O adapter module. Lets you interface with external devices without inconvenient hookup to the controller's back panel $388.00
H-78200-80 Foot switch allows hands-free operation. Includes 7-ft connecting cord; ⅛" mini jack $82.50

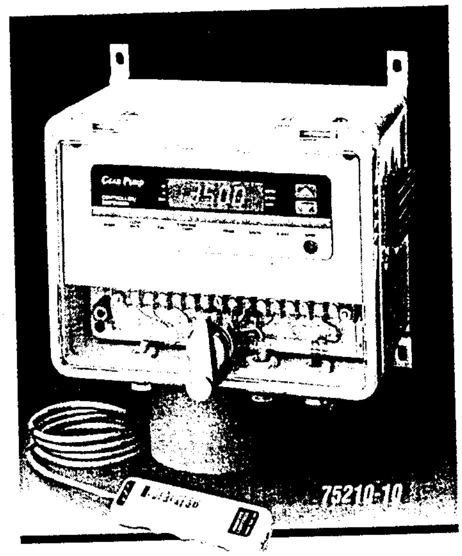
...MP HEADS

...OLE-PARMER® DIGITAL CONTROLLER/DISPENSERS

Feature copy and dispense functions



Benchtop controller features a sloped front panel for easy access to all controls.



...hese versatile new gear pump controller/dispensers accept any MICROPUMP® pump head with a standard canister (series B or D sold below). Feature prime, calibrate, dispense, and copy modes for accurate batching. Continuous-duty systems produce flow rates to 3900 ml/min; accurately dispense from 3 ml to 999 liters (speed control is ±0.3%). Systems have remote capabilities through a contact closure—useful for small-scale process applications such as fermentation and filtration.

Calibration values for 30 different MICROPUMP pump heads are stored and protected in the nonvolatile memory. You can also calibrate controller/dispenser for fluids other than water. Simply press the CAL button, let the pump run for a predetermined amount of time, then enter the correct volume of fluid dispensed. Maximum operating temperature is 104°F (40°C).

The vacuum fluorescent display can be read from a distance of 12 feet. Display indicates volume (ml, l, or oz) or flow rate (ml/min, l/min, or oz/min). Select from models with either a benchtop controller or a NEMA Type 13 wall-mount controller. All systems come with a 180-3600 rpm, NEMA Type 4X "washdown" motor (IP56 rating). Shpg wt 10 lbs (4.5 kg).

BENCHTOP CONTROLLER

Membrane keypad is sloped for easy access. Controller has a ¼" phone jack for remote start-up using optional foot switch 07595-35 (order at right). A 6-ft cable connects the motor and controller. Model 75210-00 includes a 6-ft modular line cord with U.S. plug. Model 75210-05 includes a 6-ft modular line cord with IEC 320/CEE 22 connector—please specify country of destination to obtain correct line cord. Both models have an IP43 rating; measure 9"W x 9¼"H x 5"D.

NEMA TYPE 13 WALL-MOUNT CONTROLLER

Wall mount this controller in your lab or plant. Make all connections to the front-panel terminal strip—controller's transparent cover is hinged for easy access to the controls. You can also operate the system remotely using optional hand-held remote controller 07592-80 (sold separately at right). A 24-ft cable connects the motor and controller. Both the 115 and 230 VAC models come with a 6-ft integral line cord (115 VAC model comes with U.S. three-prong plug; 230 VAC model comes with European plug). Both models have an IP55 rating and measure 10"W x 8"H x 6"D.

ORDERING INFORMATION FOR CONTROLLER/DISPENSERS

Catalog number	Power	Price
Benchtop models		
H-75210-00	115 VAC, 50/60 Hz	$1300.00
H-75210-05	230 VAC, 50/60 Hz	1300.00
NEMA Type 13 wall-mount models		
H-75210-10	115 VAC, 50/60 Hz	1530.00
H-75210-15	230 VAC, 50/60 Hz	1530.00

ACCESSORIES

H-07595-35 Foot switch for start/stop remote control of benchtop system $70.50

H-07592-80 Hand-held remote controller for use with NEMA Type 13 system. Features start/stop, reverse, momentary on (prime), and dispense/copy functions $82.50

IBM—Reg TM International Business Machines Corp.
Masterflex—Reg TM Cole-Parmer Instrument Co.
Pro-Spense—TM Cole-Parmer Instrument Co.
MICROPUMP—Reg TM Micropump Corp.
Ohaus—Reg TM Ohaus Scale Corp.
Ryton—Reg TM Phillips Petroleum Co.
Teflon, Viton—Reg TM E. I. du Pont de Nemours & Co.

Pump heads*		Max flow (ml/min)		Max pressure (psi)		Materials of construction			Temperature range	Bypass valve	Price	Service kit	
Series	Catalog number	Cole-Parmer[1]	Pro-Spense[1]	System	Diff	Body	Gears**	Seals				Catalog number	Price
Cavity-style pump heads with standard canister													
B	H-07002-16	1140	1260	300	45	316 SS	Teflon	Teflon	-50 to 130°F††	No	$405.00	H-07144-38	$136.00
B	H-07002-17	1140	1260	300	45	316 SS	Teflon	Teflon	-50 to 130°F††	Yes	405.00	H-07144-38	136.00
B	H-07002-23	2300	2600	300	45	316 SS	Teflon	Teflon	-50 to 130°F††	Yes	373.00	H-07002-08	84.50
B	H-07001-80	2300	2600	300	45	316 SS	Ryton	Teflon	-50 to 250°F	Yes	373.00	H-07001-89	84.50
B	H-07001-70	2400	2700	300	45	Ryton/316 SS	Ryton	Teflon	-50 to 250°F	Yes	267.00	—	—
B	H-07001-40	3400	3800	300	45	316 SS	Teflon	Teflon	-50 to 210°F	No	373.00	H-07001-41	84.50
Pressure-loaded pump heads with standard canister													
D	H-07002-25	60	70	300	50	316 SS	Teflon	Teflon	-50 to 130°F††	No	419.00	H-07144-42	141.00
D	H-07002-26	150	170	300	50	316 SS	Teflon	Teflon	-50 to 130°F††	No	419.00	H-07144-44	141.00
D	H-07002-27	300	335	300	50	316 SS	Teflon	Teflon	-50 to 130°F††	No	419.00	H-07144-47	141.00
D	H-07002-14	330	370	300	50	316 SS	Ryton	Teflon	-50 to 210°F	No	419.00	H-07144-34	141.00
D	H-07003-02	2000	2300	300	50	316 SS	Teflon	Teflon	-50 to 210°F	Yes	392.00	H-07003-12	101.00
D	H-07003-04	3900	4400	300	45	Ryton/316 SS	Ryton	Viton	-50 to 250°F	No	392.00	H-07003-14	101.00

*For complete information on these pump heads and service kits, see pages 1130-1131. [1]Nominal flow rate pumping water with no back pressure at 3600 rpm. ·Nominal flow rate pumping water with no back pressure at 4000 rpm. **Port size for all models is ⅛" NPT(F). ††Up to 210°F using the high-temperature seals 07002-05 on page 1130.

ISMATEC VARIABLE-SPEED DRIVES

STANDARD DIGITAL DRIVE

- *Pulseless flow from 0.3 to 6650 ml/min*
- *Numeric speed adjustment*
- *Remote control capability*

This standard variable-speed drive accepts any MICROPUMP® pump head with standard canister (series B and D). Select pump heads and service kits from the table at the bottom of the facing page.

Precisely control speed from 70 to 6100 rpm with an accuracy of ±1% of setting over full range. Electronic feedback system compensates for changes in load. Tach-generator on motor shaft produces a 0-7 VDC output signal for remote indication of motor rpm.

Use the three-digit potentiometer to set pump speed from 0.1 to 99.9%. **NOTE:** Avoid running drive continuously at less than 20% or more than 85% of full speed. Press the "max" button for extra rpm; ideal for quick pump priming.

Control input port (DB15 female connection) lets you use peripheral instruments to actuate many of the drive functions from a remote location (remote cable required). Use a remote controller (with NO contact) to turn the pump on and off; use an external control signal (0-4.7 VDC, 0-10 VDC, 0-20 mA, or 4-20 mA) to vary pump speed.

Permanent-magnet DC motor provides smooth acceleration. Motor magnetically couples to pump head so there are no shaft seals to wear out or leak. Drive housing measures 9½"W x 6⁵⁄₁₆"H x 7¹³⁄₁₆"D. Both the 110 and 220 VAC models include a 6-ft power cord with U.S. standard plug. Order drive and remote cable from the table on the facing page.

NEW PROGRAMMABLE DIGITAL DRIVE

- *LED display indicates flow rate*
- *Built-in RS-232-C interface and optional software let you automate pumping processes*

Choose this new programmable digital drive for versatility! Drive offers the same features as the standard digital drive at left plus the advantages of a built-in RS-232-C interface. Order RS-232-C interface cable 78098-50 separately below to connect drive to any IBM* PC/XT/AT* or 100% compatible computer. You can also use the optional software with additional cables to control up to eight drives simultaneously!

Front-panel keypad lets you set all operating parameters including pump speed (1-6100 rpm) and dispensing mode.The 4-digit LED with adjustable scale indicates flow rate or drive rpm. Use drive for continuous pumping or select one of the three dispensing modes for added convenience. Use the time mode to set dispense and pause times. The step mode lets you set the number of shaft rotations for precise dispensing. Use the valve mode to control an external diverter valve (not included) for dispensing two liquids in the same batch. You can even use all three modes simultaneously for maximum versatility and dispensing accuracy.

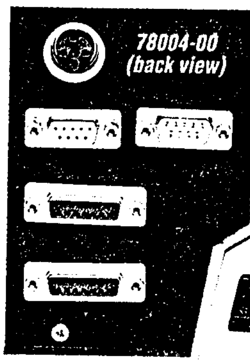
Control pump speed remotely via an analog input signal (0-4.7 VDC, 0-10 VDC, 4-20 mA, or 0-20 mA); start and stop flow remotely via contact closures. Make all remote control connections via the back panel DB15 female connector. Tachometer output sends a voltage signal (0-7 or 0-4.35 VDC) proportional to drive speed. Or, order optional software 78002-99 (sold below) to control all drive functions including calibration, ramp and on/off times, and fluid direction.

Drive measures 6"W x 10⅜"H x 8½"D: includes a 5-ft cord with U.S. standard plug. Operates on 110/220 VAC, 50/60 Hz (switch selectable). Order drive from table on facing page.

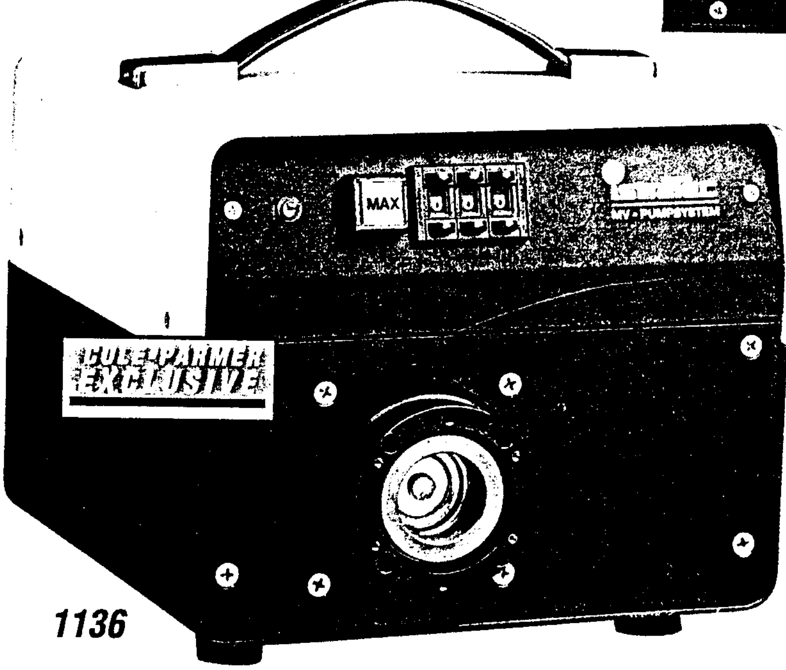
H-78002-99 Software	**$353.00**
H-78098-50 RS-232-C interface cable	**$177.00**
H-07610-25 Optional remote foot switch	**$206.00**

IBM, PC/XT/AT—Reg TM International Business Machines Corp.

Specifications for each MICROPUMP series B and D pump head are given in the table on the facing page.



Standard digital drive 07617-70 accepts any MICROPUMP® series B and D pump heads.



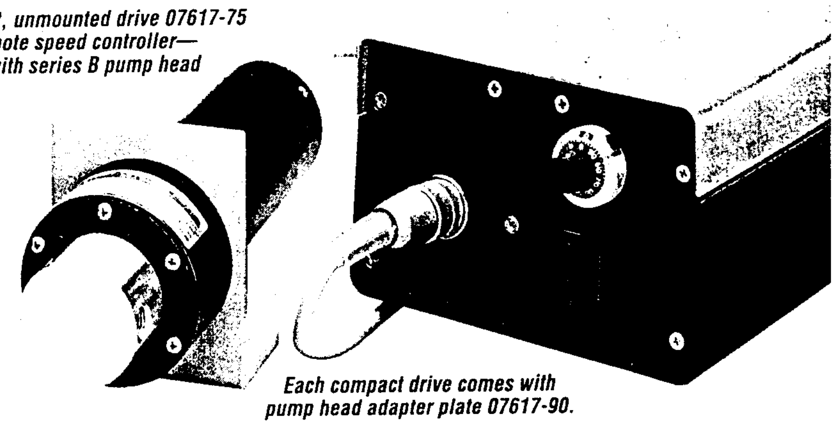
Programmable digital drive 78004-00 shown with MICROPUMP® series D pump head 07002-14.

PUMPS

Positive displacement: Gear

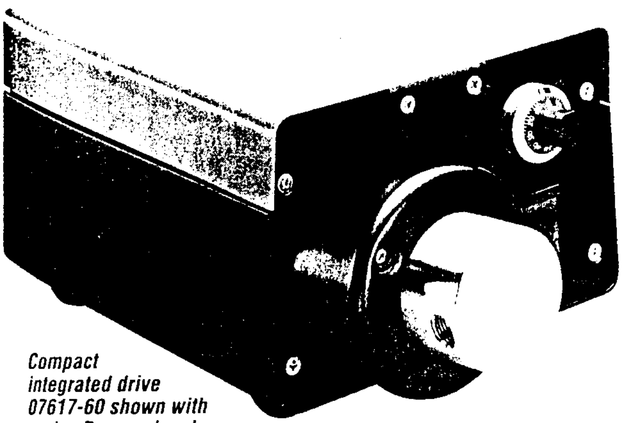
COMPACT DRIVES

- *Flow from 0.1 to 4700 ml/min*
- *Remote control capability*



Compact, unmounted drive 07617-75 with remote speed controller—shown with series B pump head

Each compact drive comes with pump head adapter plate 07617-90.



Compact integrated drive 07617-60 shown with series B pump head

Use these space saving, variable-speed drives with MICROPUMP pump heads with standard canister (series B and D except models 07003-02 and -04). Each compact drive comes with adapter plate 07617-90 for mounting pump head.

Adjust speed with the 10-turn potentiometer—get linear speed regulation from 50 to 5000 rpm with an accuracy of ±1% over the full range. **NOTE:** Avoid running drives continuously at less than 20% or more than 85% of full speed.

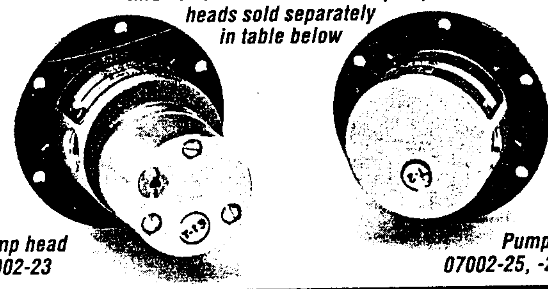
Five-pin remote-input port on back panel accepts a 0-4.7 VDC, 0-10 VDC, 0-20 mA, or 4-20 mA signal for speed control; couples with relay contact for on/off control (order remote cable from table at right).

Choose either an integrated drive or a modular drive. The integrated drive measures just 7¾"L x 5"W x 3¾"H. The modular drive connects to a remote speed controller via a 6-ft cord (drive measures 6¾"L x 2½"W x 3⅛"H; controller measures 7¾"L x 5"W x 3¾"H). Both the integrated and the modular drives are available in 110 and 220 VAC versions; include a 6-ft power cord with U.S. standard plug.

H-07617-90 Replacement adapter plate for mounting MICROPUMP series B and D pump heads (except models 07003-02 and -04) on compact drives $13.75

ORDERING INFORMATION FOR DRIVES

Catalog number	Power VAC, Hz	Shpg wt lbs (kg)	Price	Remote cable Cat. no.	Remote cable Price
Standard digital drive					
H-07617-70 **H-07617-72**	110, 60 220, 50	19 (8.6) 19 (8.6)	**$2060.00** **2060.00**	**H-07339-50**	**$136.00**
Programmable digital drive					
H-78004-00	115/230, 50/60	16 (7.3)	**2820.00**	—	—
Compact integrated drive					
H-07617-60 **H-07617-62**	110, 60 220, 50	7 (3.2) 7 (3.2)	**1390.00** **1500.00**	**H-07339-54**	**82.50**
Compact modular drive and controller					
H-07617-75 **H-07617-77**	110, 60 220, 50	6 (2.7) 6 (2.7)	**1590.00** **1590.00**	**H-07339-54**	**82.50**



MICROPUMP®series B and D pump heads sold separately in table below

Pump head 07002-23

Pump heads 07002-25, -26, -27

SPECIFICATIONS AND ORDERING INFORMATION FOR MICROPUMP® PUMP HEADS

Pump heads* Series	Pump heads* Cat. no.	Max flow (ml/min) Digital	Max flow (ml/min) Compact	Max pressure (psi) System	Max pressure (psi) Diff	Materials of construction Body	Materials of construction Gears†	Materials of construction Seals	Temperature range	Bypass valve	Price	Service kit Cat. no.	Service kit Price
Cavity-style pump heads with standard canister													
B B B	**H-07002-16** **H-07002-17** **H-07002-23**	1950 1950 3900	1580 1580 3200	300 300 300	45 45 45	316 SS 316 SS 316 SS	Teflon® Teflon Teflon	Teflon Teflon Teflon	-50 to 130°F‡ -50 to 130°F‡ -50 to 130°F‡	No Yes Yes	**$405.00** **405.00** **373.00**	**H-07144-38** **H-07144-38** **H-07002-08**	**$136.00** **136.00** **84.50**
B B	**H-07001-80** **H-07001-40**	3900 5730	3200 4700	300 300	45 45	316 SS 316 SS	Ryton® Ryton	Teflon Teflon	-50 to 250°F -50 to 210°F	Yes Yes	**373.00** **373.00**	**H-07001-89** **H-07001-41**	**84.50** **84.50**
Pressure-loaded pump heads with standard canister													
D D D	**H-07002-25** **H-07002-26** **H-07002-27**	104 250 510	85 210 420	300 300 300	50 50 50	316 SS 316 SS 316 SS	Teflon Teflon Teflon	Teflon Teflon Teflon	-50 to 130°F‡ -50 to 130°F‡ -50 to 130°F‡	No Yes Yes	**419.00** **419.00** **419.00**	**H-07144-42** **H-07144-44** **H-07144-47**	**141.00** **141.00** **141.00**
D	**H-07002-14**	560	460	300	50	316 SS	Ryton	Teflon	-50 to 210°F	Yes	**419.00**	**H-07144-34**	**141.00**
D	**H-07003-02**	3440	—	300	50	316 SS	Teflon	Teflon	-50 to 210°F	Yes	**392.00**	**H-07003-12**	**101.00**
D	**H-07003-04**	6650	—	300	45	Ryton/316 SS	Ryton	Viton®	-50 to 250°F	Yes	**392.00**	**H-07003-14**	**101.00**

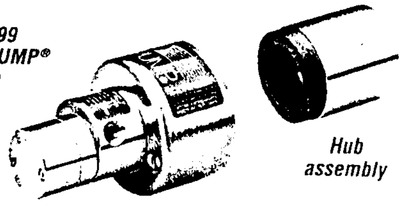
*See pages 1130-1131 for complete information on these pump heads and service kits. †Port size for all models is ⅛" NPT(F). ‡Temperatures up to 210°F can be reached using optional high-temperature seals 07002-05 on page 1130.

MICROPUMP—Reg TM Micropump Corp. **Ryton**—Reg TM Phillips Petroleum Co. **Teflon, Viton**—Reg TM E. I. du Pont de Nemours & Co.

MICROPUMP® PUMP HEAD ADAPTER KITS

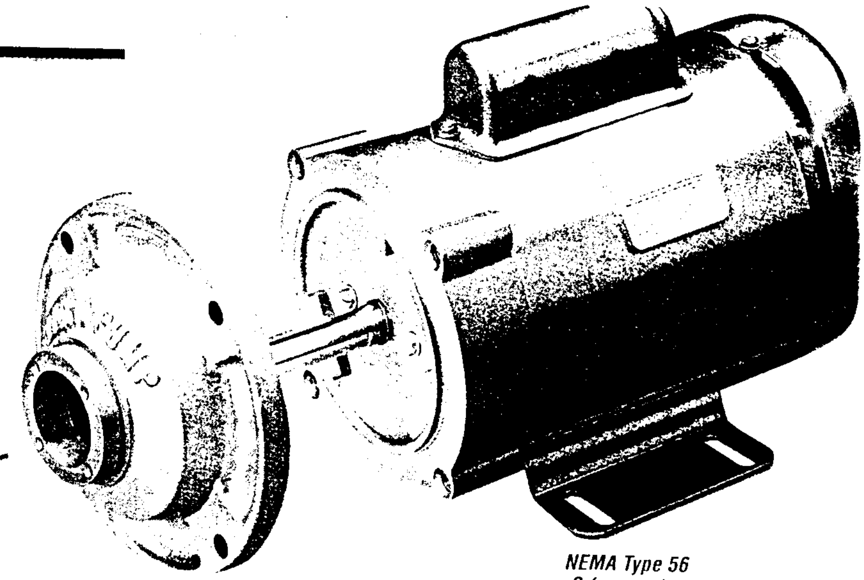
Use these adapter kits to attach MICROPUMP® pump heads with standard canister (series B and D; pages 1130-1131) to your own specialty motor. Choose from four types including IEC/ISO kits for metric frame drives.

Adapter kit 07003-99 couples a MICROPUMP® series B or D pump head to your NEMA Type 56



Hub assembly

MICROPUMP® pump head



Metal adapter

NEMA Type 56 C-face motor

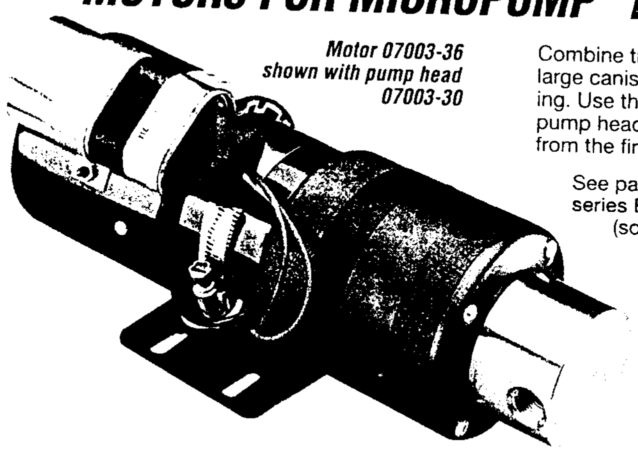
H-07003-97 IEC 72/ISO 71 pump head adapter kit for IEC/ISO 71 drives.Includes hub assembly (drive magnet), hex key, mounting bolts, and mounting plate. Shpg wt 3 lbs (1.4 kg) $228.00

H-07003-98 IEC 72/ISO 63 pump head adapter kit for IEC/ISO 63 drives. Includes hub assembly (drive magnet), hex key, mounting bolts, and mounting plate. Shpg wt 3 lbs (1.4 kg) $228.00

H-07003-99 NEMA Type 56 C-face pump head adapter kit for 3450 rpm, 56 C-face drives. Includes metal adapter, hub assembly (drive magnet), mounting screws and bolts, and an Allen wrench. Shpg wt 3 lbs (1.4 kg) $228.00

H-07002-15 MICROPUMP pump head adapter for 600 rpm Masterflex® L/S drives $144.00

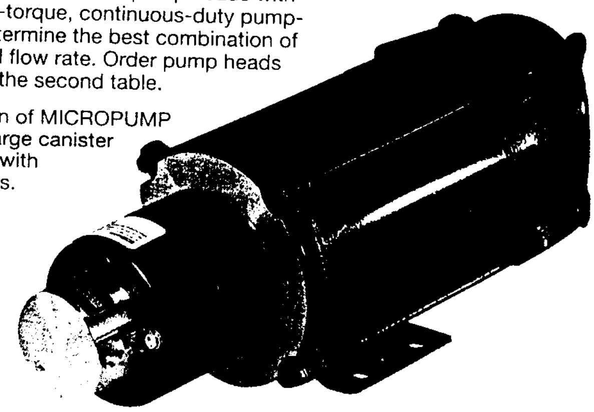
MOTORS FOR MICROPUMP® PUMP HEADS WITH LARGE CANISTER



Motor 07003-36 shown with pump head 07003-30

Combine these powerful motors with MICROPUMP pump heads with large canister (series E and G) for high-torque, continuous-duty pumping. Use the table directly below to determine the best combination of pump head and motor for your desired flow rate. Order pump heads from the first table; order motors from the second table.

See page 1132 for a full description of MICROPUMP series E and G pump heads with large canister (sold below) and pump heads with 56 C-face flange adapters.



Motor 07002-49 shown with pump head 07003-06

See pages [illegible] for a wide selection of motors and controllers. See pages [illegible] for our Masterflex® pumps.

SPECIFICATIONS AND ORDERING INFORMATION FOR MICROPUMP® PUMP HEADS

Pump heads		Max flow (liters/min) using indicated pump motor					Price	Service kits	
Series	Cat. no.	07002-51, -49	07003-36	07003-37	07003-83	07003-82		Cat. no.	Price
E	H-07001-92	—	5.4	5.4	5.4	5.5	$3680.00	—	—
E	H-07001-94	—	10.9	10.9	10.9	11.3	4220.00	—	—
G	H-07003-06	3.0	—	—	—	—	816.00	H-07003-16	$114.00
G	H-07003-08	5.4	—	—	—	—	816.00	H-07003-18	114.00
G	H-07003-30	—	5.5	4.5	5.5*	7.4†	855.00	H-07003-38	114.00
G	H-07003-31	—	11.3	9.0	11.3*	14.9†	855.00	H-07003-39	114.00

*Due to torque limitations, maximum intermittent pressure may be lower in these pump head/motor combinations.
†These pump head/motor combinations require 40 psi air to inlet pressure.

SPECIFICATIONS AND ORDERING INFORMATION FOR MOTORS

Cat. no.	Type	rpm	Motor	hp	Power source	Termination	Dimensions	Shpg wt	Price
H-07002-51	AC	3400	TEFC/PSC	0.125	115/230 VAC, 50/60 Hz, 2.1 A	14" wire leads	7½"L x 4¾"W x 5¾"H	9 lbs (4.1 kg)	$340.00
H-07003-36	AC	3200	TEFC/PSC	0.250	115 VAC, 50/60 Hz, 3.0 A	15" wire leads	7½"L x 4¾"W x 5½"H	10 lbs (4.5 kg)	340.00
H-07003-37	AC	3200	TEFC/PSC	0.250	230 VAC, 50 Hz, 1.5 A	15" wire leads	7½"L x 4¾"W x 5½"H	10 lbs (4.5 kg)	340.00
H-07002-49	AC	3150	XPRF/PSC	0.170	115/230 VAC, 50/60 Hz, 1.8 A	6" wire leads	12¼"L x 4¾"W x 5¼"H	25 lbs (11.3 kg)	634.00
H-07003-83	AC	3150	XPRF/PSC	0.170	115/230 VAC, 50/60 Hz, 2.2 A	6" wire leads	12¼"L x 4¾"W x 5¼"H	20 lbs (9.1 kg)	634.00
H-07003-82	Air	4300	Air/vane	0.300	10 to 16 SCFM, 20 to 60 psi	¼-28 UNF	8¾"L x 4¾"W x 6"H	7 lbs (3.2 kg)	653.00

TUTHILL MAGNET DRIVE GEAR PUMPS

1 BULLETIN
FIFTH EDITION

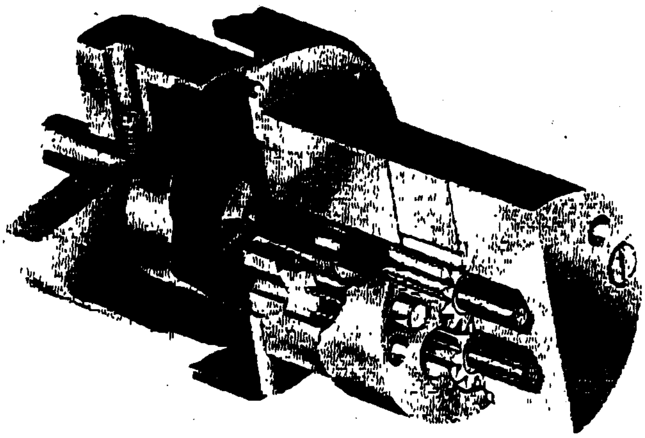
D-SERIES Stainless Steel Seal-less Hi-Torque Magnet Drive Gear Pumps

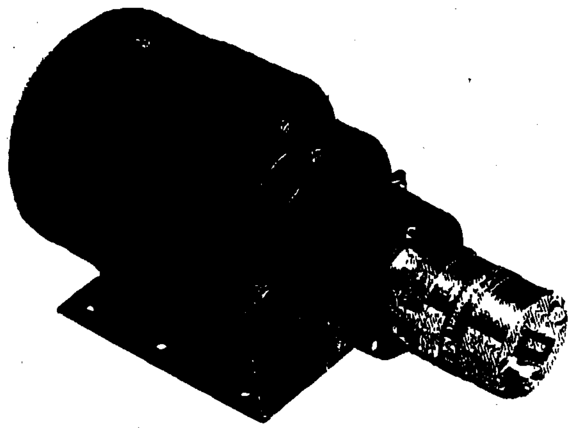
Flow Rates to 2 GPM

Temperatures to 350° F

Pressures to 250 PSID

Viscosities to 2000 cP





- **Chemical Handling**
- **Oil Filtration**
- **Negative Pressure**
- **Solvent Handling**
- **Instrumentation Cooling**
- **Pilot Plant**
- **Sampling**
- **Proportioning**
- **Laboratory**
- **Refrigerant Recycling**
- **Additive Delivery**
- **Seal Flush**
- **Fluid Transfer**
- **Spraying**

STANDARD PUMPHEAD SPECIFICATIONS

- 30 in oz Magnetic Coupling
- Pump Body, Cavity Plate & End Cap — 316 Stainless Steel, Hastelloy or Titanium Available
- Gears — Nickel Alloy Driving, Carbon/Teflon filled Ryton Driven
- Gear Shafts — 316 Stainless Steel
- Bearings — Carbon/Teflon filled Ryton
- By-Pass/Pressure Relief — Externally Adjustable
- O-Rings — Virgin Teflon
- Driven Magnet — Barium Ferrite
- Magnet Cup — 316 Stainless Steel
- 1/8 N P T Straight Through Porting (1/4 N P T and other ports Available)
- System Pressure 500 PSIG

"LEAK-FREE MAGNET DRIVE MAKES THE DIFFERENCE."

TUTHILL CORPORATION | Tuthill Pump Co. of California
5143 Port Chicago Highway
Concord, California USA 94520
Tel 510 676-8000 Fax 510 676-8151

D SERIES — PUMP AND MOTOR SELECTION GUIDE
30 INCH OUNCE MAGNETIC TORQUE

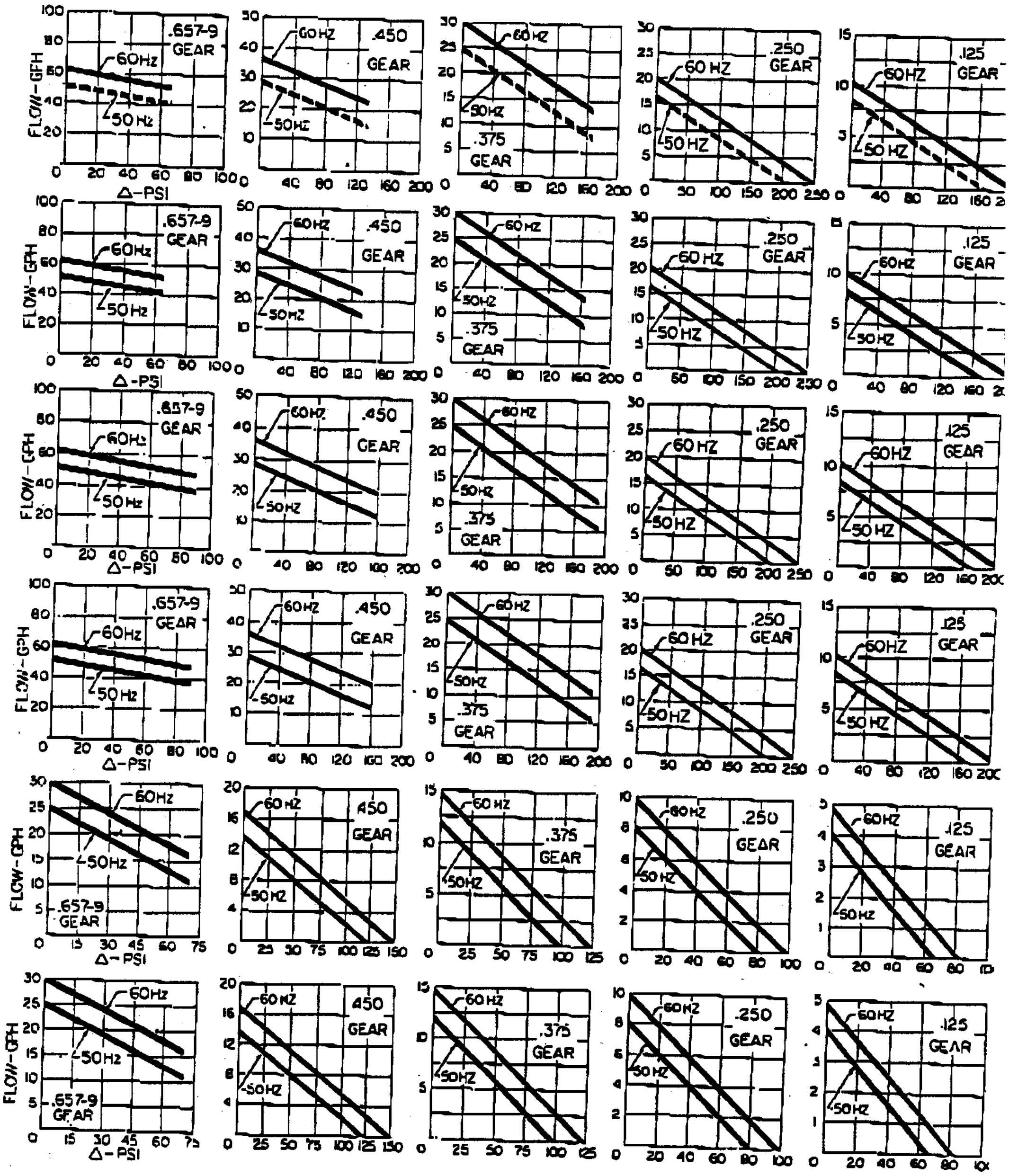
MODEL NUMBER = PUMPHEAD + MOTOR & DRIVE

PUMPHEAD	GEAR* WIDTH	MOTOR & DRIVE
D 9863 MC D 9045 MC D 9046 MC D 9049 MC D 9006 M	.657-9 .450 .375 .250 .125	D 5759 115 VAC 60 HZ TEFC - 1/13 HP 2.8 AMP Line Cord 3500 RPM - No Load
D 9863 MC D 9045 MC D 9046 MC D 9049 MC D 9006 M	.657-9 .450 .375 .250 .125	D 5804 115/230 VAC - 50/60 HZ TEFC - 1/13 HP 2.3/1.2 AMP Wire Leads 3500 RPM - No Load
D 9863 MC D 9045 MC D 9046 MC D 9049 MC D 9006 M	.657-9 .450 .375 .250 .125	D 5679 115/230 VAC - 50/60 HZ Expl. Proof - 1/4 HP 2.1/1.0 AMP - Wire Leads P.S.C. - 3500 RPM - No Load
D 9863 MC D 9045 MC D 9046 MC D 9049 MC D 9006 M	.657-9 .450 .375 .250 .125	D 6870 115/230 VAC - 50/60 HZ P.S.C. - TEFC - 1/10 HP 1.48/.74 AMP - Wire Leads 3500 RPM - No Load
D 9863 MC D 9045 MC D 9046 MC D 9049 MC D 9006 M	.657-9 .450 .375 .250 .125	D 7697 115/230 VAC - 50/60 HZ TEFC - 1/20 HP 1.5/.75 AMP - Wire Leads 1750 RPM - No Load
D 9863 MC D 9045 MC D 9046 MC D 9049 MC D 9006 M	.657-9 .450 .375 .250 .125	D 5676 115/230 VAC - 50/60 HZ Expl. Proof - 1/8 HP 2.4/1.2 AMP - Wire Leads P.S.C. - 1750 RPM - No Load

NOTE: FOR FLOWS UP TO 2 GPM SEE BULLETIN 5

*OTHER GEAR WIDTHS AVAILABLE— SEE PAGE 24 FOR OPTIONS

PUMP PERFORMANCE CURVES
VARIOUS GEAR WIDTHS AND MOTORS - 77°F WATER



LEGEND: CONTINUOUS DUTY ———— INTERMITTENT DUTY — — — —

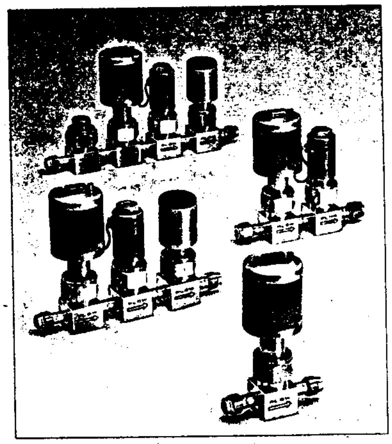
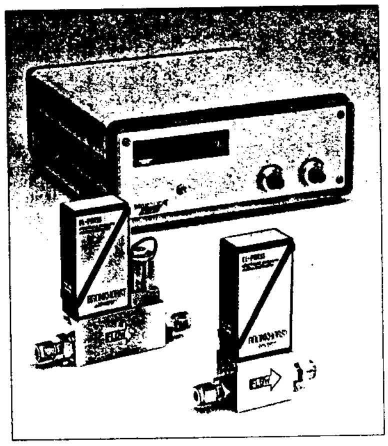
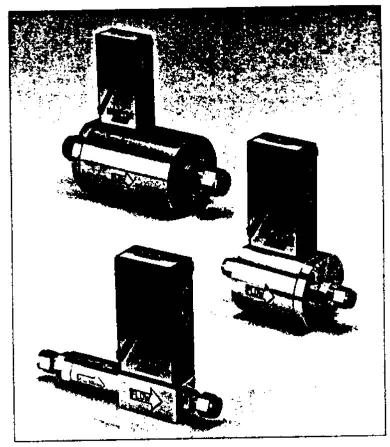
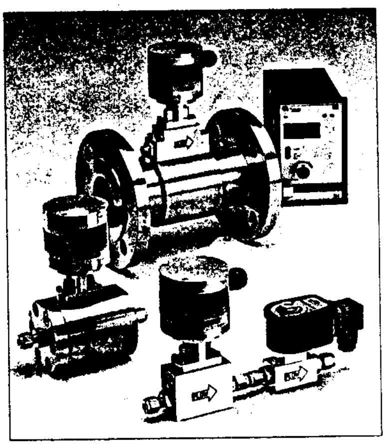
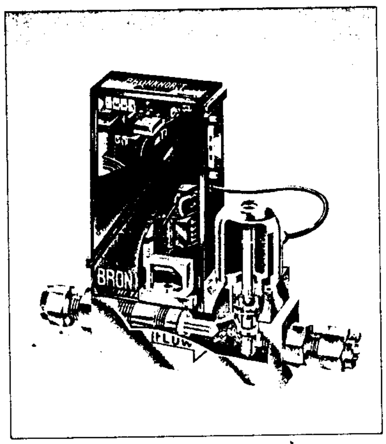
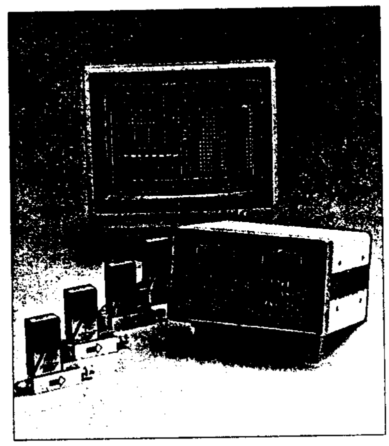
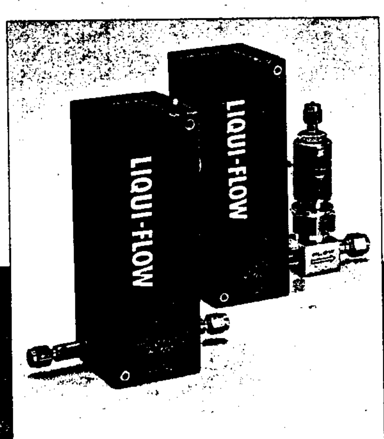
MAXIMUM DIMENSIONS AND WEIGHTS FOR ABOVE:

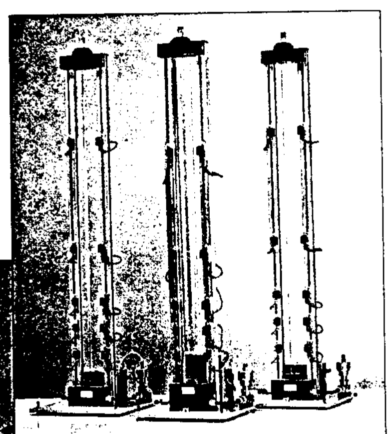
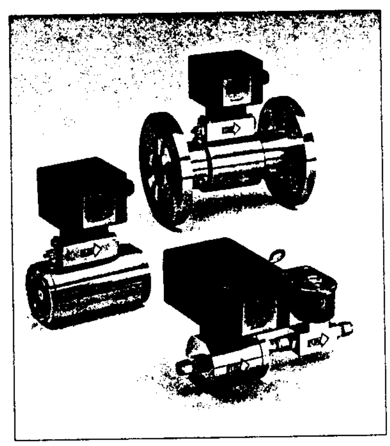
MODEL NUMBER	MAX. DIMENSIONS H x W x L	WT.
D 9863 MC - D 5759	4.38 x 4.00 x 9.50	7.5 lbs.
D 9863 MC - D 5804	4.38 x 4.00 x 9.50	7.5 lbs.
D 9863 MC - D 5798	4.38 x 4.00 x 9.50	7.5 lbs.

MODEL NUMBER	MAX. DIMENSIONS H x W x L	WT.
D 9863 MC - D 6870	5.25 x 4.00 x 9.75	8 lbs.
D 9863 MC - D 5679	5.25 x 5.00 x 15.25	20 lbs.
D 9863 MC - D 5676	5.25 x 5.00 x 15.25	20 lbs.

APPENDIX 4

Mass Flow and Pressure Measurement and Control

Koning Willem I Award

ISO 9001

- Certified ISO-9001
- Innovative
- Wide product range
- Reliable
- Global service

BRONKHORST HI-TEC

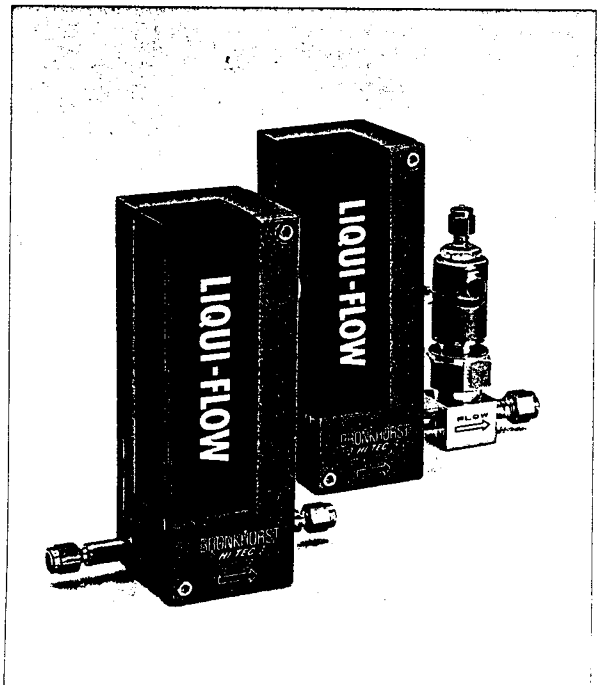
LIQUI-FLOW Mass Flow Meters/Controllers

General

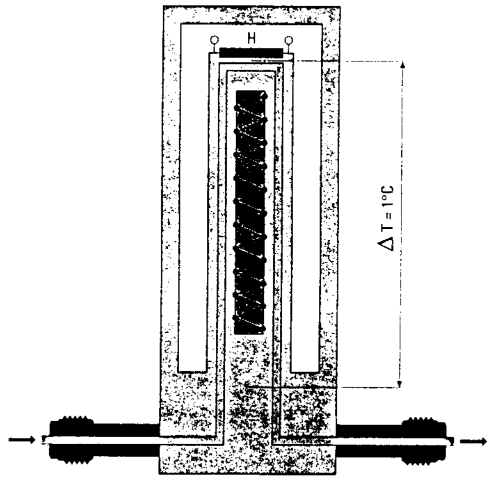
The LIQUI-FLOW series thermal mass flow meters/controllers for liquids are suitable for measuring flows of 0...5 g/h up to 0...1000 g/h, at pressures from vacuum up to 400 bar.
The flow meter is basically an obstructionless tube with an internal diameter of 1 mm, bent in U-form, with patented heater/sensor. In the sensor, the liquid gets merely 1 degree warmer than the environmental temperature, so that the chance that the liquid will decompose or gas-out is negligible.
The instrument has a "thru-flow" measuring principle and it is insensitive to its mounting position. Moreover, the flowmeter can be sterilized and does not contain any moving parts or elastomer seals.
The LIQUI-FLOW meter has an integrated control function and can be connected to a COMBI-FLOW control valve to form a control loop. The control valve with standard purge connection on the top of the sleeve takes care of steady flow control, not pulsating, even when controlling flows lower than 1 g/h.

Applications in

- Pharmaceutical industry
- Food industry
- Biotechnical industry
- Analytical laboratories
- Semiconductor industry
- Evaporation processes (see page 15)



Measuring Principle



Thermopile with approx. 5000 Thermoelements

Features

- Thru-Flow measurement
- 1°C temperature rise in sensor
- Superstable zero
- Attitude insensitive
- Wide flow ranges 1 : 50
- Sterilizable
- Orbitally welded
- Metal sealed

Flow Capacities (based on water)

Mass Flow Meters:

Series L1:	min.	0,1 5	g/h
	max.	2 100	g/h
Series L2:	min.	2 100	g/h
	max.	20 1000	g/h

Mass Flow Controllers:

Series L1C2:	min.	0,1 5	g/h
	max.	2 100	g/h
Series L2C2:	min.	2 100	g/h
	max.	20 1000	g/h

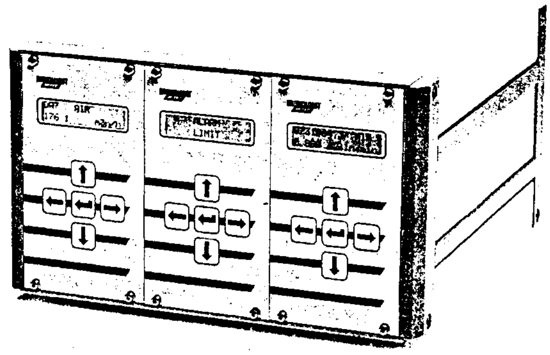
Power Supply/Readout Systems

Digital Single Channel Module; Series E-7000

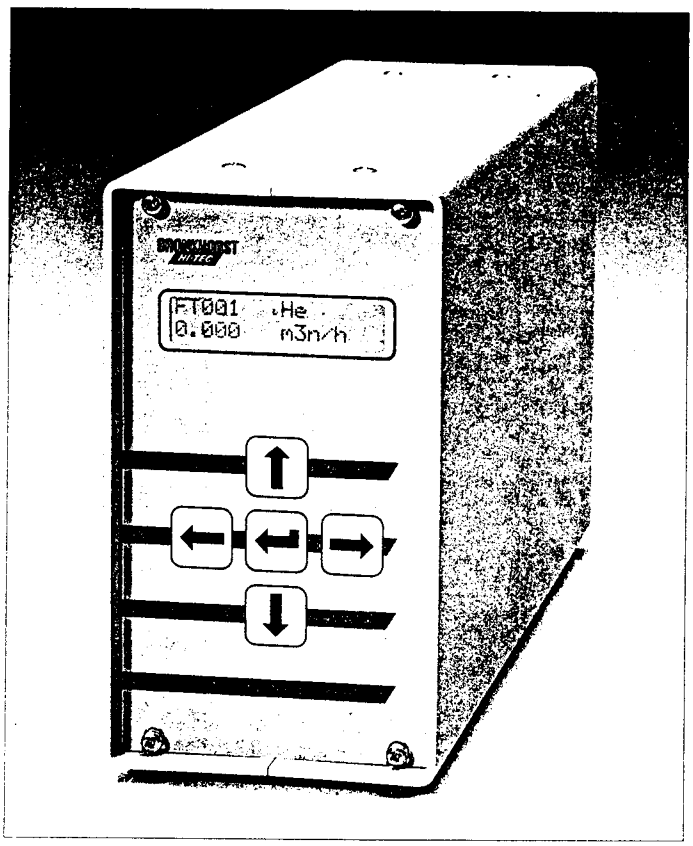
Bronkhorst High-Tech B.V. offers the Digital Single Channel Control Module for use with Thermal Mass Flow Controllers, Electronic Pressure Controllers and other transmitters and transducers or, as in master/slave control systems, in combination with these.

The Bronkhorst Hi-Tec E-7000 Series FLOW-BUS is designed to easily enable the user through a menu format to program and power one meter or controller.

The micro-processor based unit offers great flexibility in indication of tags, fluid names and counter units in combination with measuring and setpoint values, both in percentages or actual units.
Furthermore the polynominal function of the calibration curve, offering an accuracy of ± 0,5% off reading plus ± 0,1% full scale, can be stored.



E-7100 3-CHANNEL EXECUTION



Multi-Channel Executions; Series E-7000

Based on the modular technique of the single channel modules, it is easy to assemble multi-channel executions. This way 3 channels fit into a 1/2 19" housing and 6 channels fit into a 19" housing, either for rack mount or table top.

Features

A user friendly readout/control/alarm/totalization module; supply voltage 100...240 Vac, 24 Vac or 24 Vdc; with 5-key push-button menu format for:

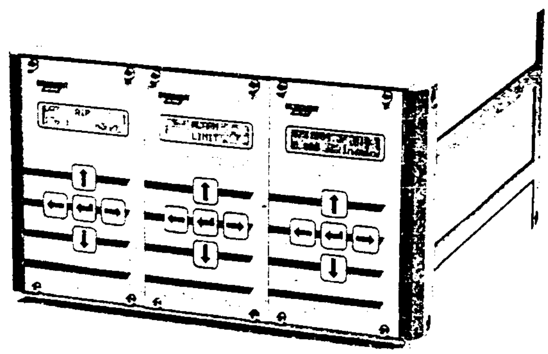
- operation with digital or analog instruments
- direct or percentage reading
- internal or external setpoint mode
- master/slave control mode
- totalizer/batchcounter function
- one programmable alarm function
- one NO/NC relay
- storage of polynominal calibration function
- CE certification

DIGITAL SINGLE CHANNEL MODULE; SERIES E-7000

Bronkhorst High-Tech B.V. offers the Digital Single Channel Control Module for use with Thermal Mass Flow Controllers, Electronic Pressure Controllers and other transmitters and transducers or, as in master/slave control systems, in combination with these.

The Bronkhorst Hi-Tec E-7000 Series FLOW-BUS is designed to easily enable the user through a menu format to program and power one meter or controller.

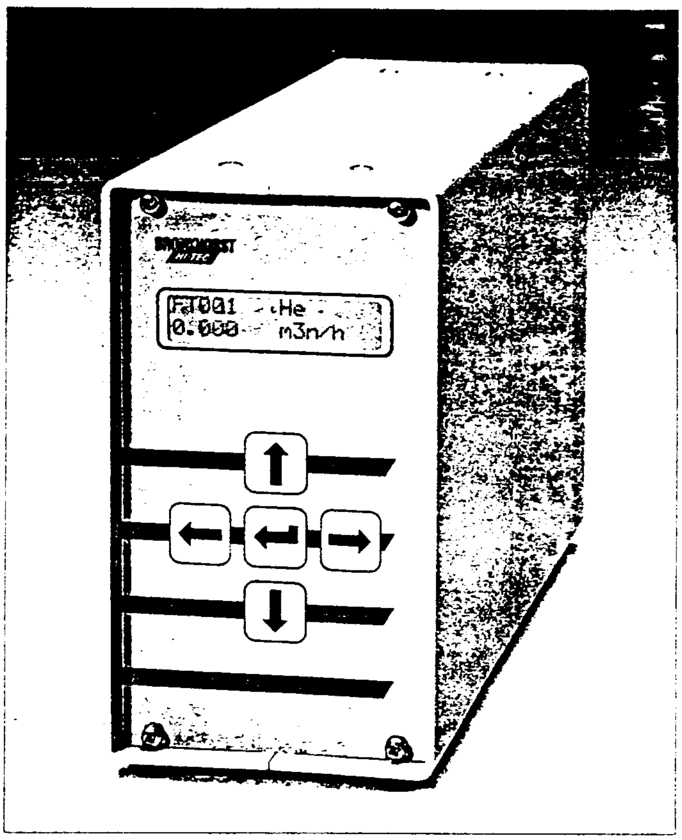
The micro-processor based unit offers great flexibility in indication of tags, fluid names and counter units in combination with measuring and setpoint values, both in percentages or actual units.
Furthermore the polynominal function of the calibration curve, offering an accuracy of ± 0,5% off reading plus ± 0,1% full scale, can be stored.



E-7100 3-CHANNEL EXECUTION

MULTI-CHANNEL EXECUTIONS; SERIES E-7000

Based on the modular technique of the single channel modules, it is easy to assemble multi-channel executions. This way 3 channels fit into a 1/2 19" housing and 6 channels fit into a 19" housing, either for rack mount or table top.



FEATURES

A user friendly readout/control/alarm/totalization module; supply voltage 100...240 Vac, 24 Vac or 24 Vdc; with 5-key push-button menu format for:

- operation with digital or analog instruments
- direct or percentage reading
- internal or external setpoint mode
- master/slave control mode
- totalizer/batchcounter function
- one programmable alarm function
- one NO/NC relay
- storage of polynominal calibration function
- CE certification

APPENDIX 5

Wägezelle
Load cell

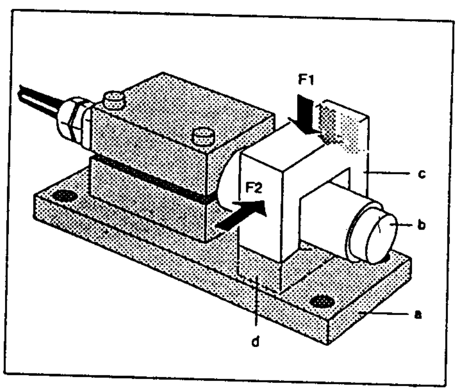
1kN.....500kN

Die Wägezelle, bestehend aus Messzelle, Bodenplate mit Halteblock und oberes Joch, misst die Scherkraft und ist weitgehend unbeinflusst, wo die Last im aktiven Teil aufliegt. Es sind keine zusätzlichen Befestigungen oder Querlenker erforderlich. Eine Abhebesicherung (unteres Joch) ist als Option erhältlich.

wichtige Merkmale
- hohe Genauigkeit und Reproduzierbarkeit
- Keine Falschmessung bei Temperaturausdehnung der Konstruktion
- Gegen Vibration unempfindlich
- Querkräfte haben keinen Einfluss
- einfache Montage

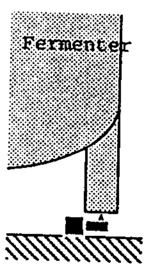
The load cell consisting of measuring cell, base plate, fixing block and yoke measures the shear force. It is practically irrelevant where or how the actual load is distributed on the cells. Additional fixations or guides are not necessary. For additional safety to prevent any lift offs the lower yoke optional can be used.

important characteristics
- high precision- and reproducibility
- no faulty readings because of expansion of the construction due to temperature changes
- insensible to fibrations
- cross force do not influence the measuring result
- easy installation



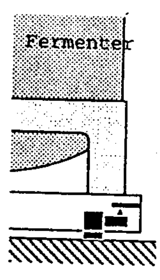
a	Bodenplatte	base plate
b	Messzelle	measuring cell
c	oberes Joch	upper yoke
d	unteres Joch (Option)	lower yoke (optional)
F1	Krafteinleitungspunkt, auf Zylinder verschiebbar	force absorbtion on the cylinder shiftable
F2	Querkraft kann bis 100% des Messbereiches ausmachen	cross force can be up to 100% of the measuring range

Anwendungsbeispiele / application examples



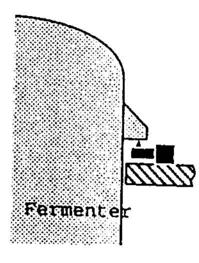
Wägezelle unter Beinstütze montiert

load cell under feet



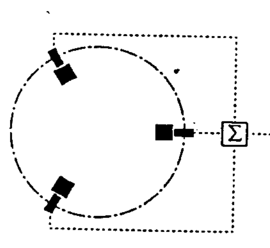
Wägezelle im Behältersockel eingebaut

load cell installed in pedestal



Wägezelle unter Aufhängevorrichtung montiert

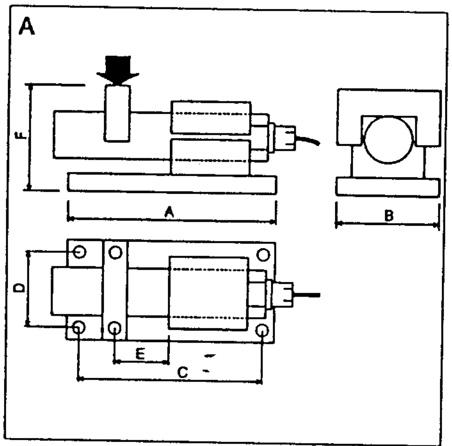
load cell on vessel suspension system



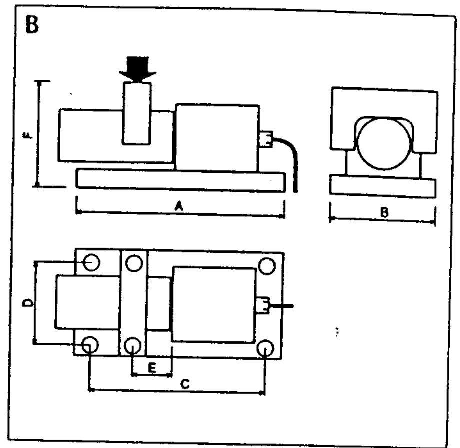
Standardanordnung bei Behälterwagen. Die Wägezellen werden sternförmig angebracht. Dadurch ist der Behälter autom. festgehalten.

basic arrangement for load cells installed evenly distributed to hold the vessel firmly in place.

1kN.....500kN



Type A 1kN, 2kN (500kN)



Type B 5kN 200kN

Typ A weist eine höhere Genauigkeit auf als Typ B.
Der Zylinder ist horizontal einfach zu de/montieren.

Type A has a higher precision and the cylinder is easely mounted/demounted horizontally.

Type	kN*	kg**	Liter/litre***	A	B	C	D	E	F	Art. No.
A	1	...300	...150l	175	75	151	51	35	81	50940
A	2	...600	150...300 l	175	75	151	51	35	81	50941
B	5	...1500	400...750 l	205	110	175	80	40	110	50942
B	10	...3000	1000...1500 l	205	110	175	80	40	110	50943
B	20	...6000	2000...3000 l	205	110	175	80	40	110	50944
B	50	...15000	4500...10000 l	260	150	230	115	60	149	50945
B	100	...30000	12000...18000 l	300	180	260	134	60	172,5	50946
B	200	...60000	20000...30000 l	340	200	290	160	60	206	50947
A	500	...150000	50000...... l	-	-	-	-	-	-	50948

* Nennkraft von 1 Wägezelle
** max. Wägebereich von 3 Wägezellen
*** Fermenterinhalt

* rated load of 1 load cell
** max. measuring range of 3 load cells
*** fermenter volume

Technische Daten	Technical data	Type A	Type B
Nennkraft	rated load	1kN, 2kN	5...200kN
Genauigkeit	precision	0,05%	0,1%
Reproduzierbarkeit	repeatability	0,01%	0,02%
zulässige Überlast	overload, safe	100%	50%
Seitenkraft max.	side load	100%	100%
Werkstoff	material	stainless steel	
Temperaturbereich	temperature range	-40.....+100°C	

% der Nennkraft / % of rated load

Gewichtssonden

zur kontnuierlichen Bestimmung der Flüssigkeitsmenge in Bioreaktoren, Vorlagentanks und drucklosen Behältern

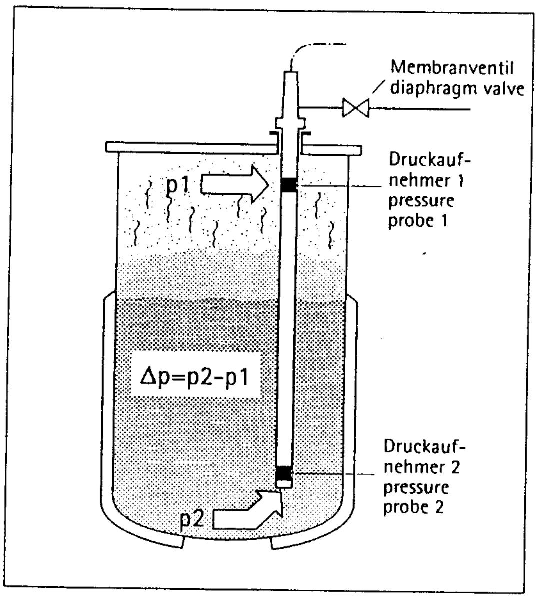
- millimetergenau
- leicht einbaubar in normierten ø25mm-Stutzen
- Elektronikteil (Verstärker) für 4-20 mA-Signal ist im Sensorgehäuse integriert
- Gemessen wird die Flüssigkeitssäule über der Messzelle
- Sondenlänge und Druckaufnehmerempfindlichkeit werden dem Reaktor angepasst
- bestehende Anlagen lassen sich leicht nachrüsten
- temperaturbeständig bis 130 °C

Weighing probes

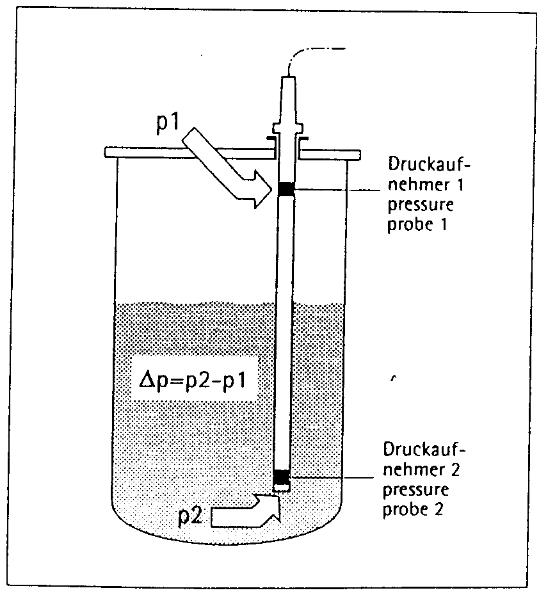
for the continuous measurement of liquid volume in bioreactors, storage tanks and non-pressure vessels

- up to the next millimeter
- easy installation in a standard 25mm port
- electronics integrated in the sensor head part (amplifier) for 4-20mA signal
- the liquid level above the measuring cell is measured
- the length and the sensitivety of the probe are individualy adjusted for each reactor
- existing installations can be easely retrofitted
- temperature resistant up to 130 °C

Gewichtssonde, sterilisierbar
Weighing probe, sterilisable



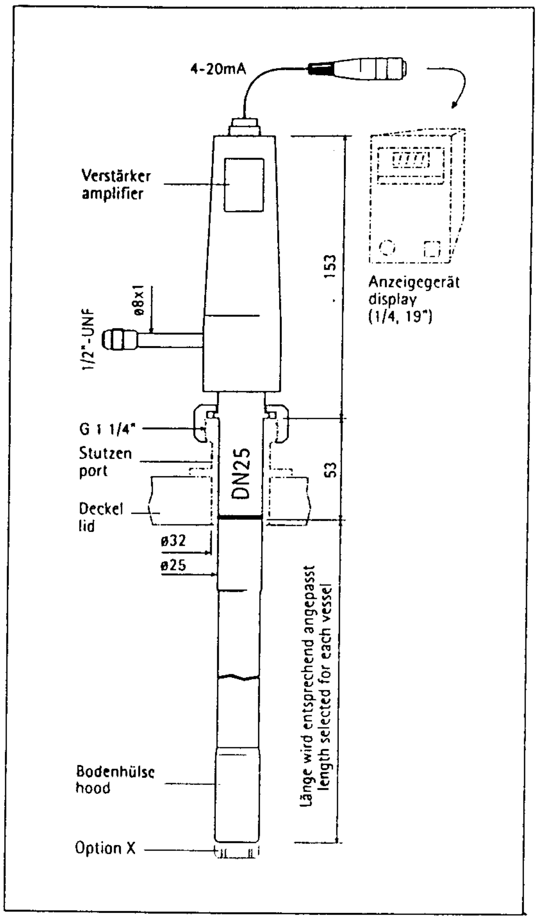
Gewichtssonde für drucklose Behälter
Weighing probe for non-pressure vessels



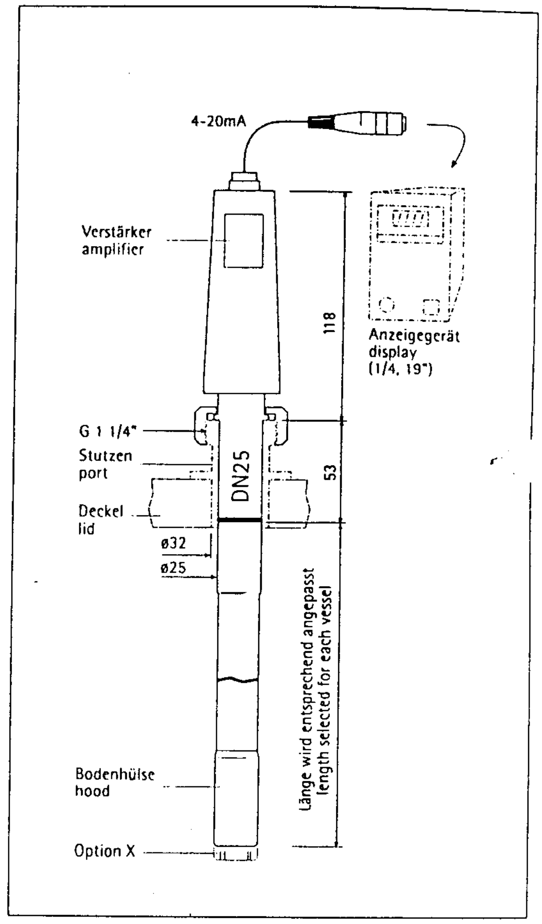
Δp	Druckdifferenz
p1	atmosphärischer Druck
p2	hydrostatischer Druck
VB	Vollbereichssignal

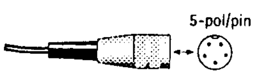
Δp	pressure difference
p1	atmospheric pressure
p2	hydrostatic pressure
VB	full range signal

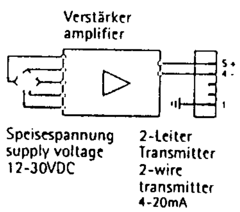
Gewichtssonde, sterilisierbar
Weighing probe, sterilisable



Gewichtssonde für drucklose Behälter
Weighing probe for non-pressure vessels





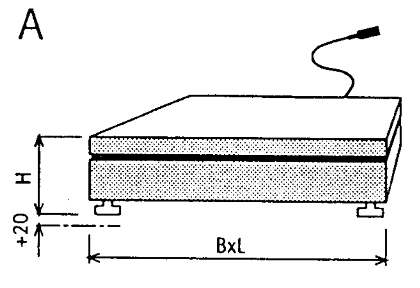


Technische Daten	Technical data					
Betriebstemperatur	operating temperature				max. 130 °C	
Werkstoff: Mediumberührte Teile	material: parts in contact with medium				1.4435 (31	
Messprinzip	measurement principle				Piezoresistiv	
Messbereiche bis	measuring range up to	1	2	5	10	m
Überlast (Differenzdruck)	overload (pressure difference)	2,5	2,5	2,5	3	bar
Vollbereichssignal (VB)	full range signal (VB)	80	150	300	400	mV
Linearität	linearity	±1	±3	±10	±24	mm
Repetierbarkeit	repetition	±1	±2	±5	±10	mm
Auflösung	accuracy				$< 10^{-5}$ VB	

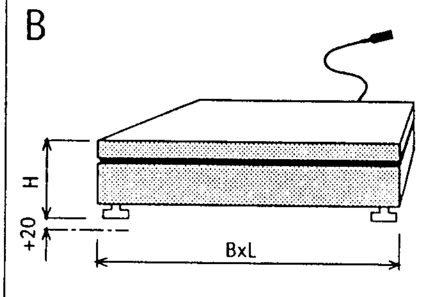
Bestellangaben	details of ordering		Art. No.
Gewichtssonde*, sterilisierbar	weighing probe*, sterilisable		11857
Gewichtssonde* für drucklose Behälter	weighing probe* for non-pressure vessels		11856
Strömungsdämpfende Bodenhülse	flow absorbing hood		44662
O-Ring-Satz	O-ring set	sterilisierbar/sterilisable	51251
		drucklos/non-pressure	51250

* mit Kabel u. Stecker
* with cable and cable plug

Plattformwaagen
Platform scales



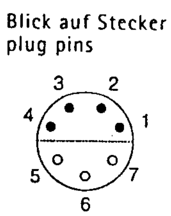
Typ A, Wägebereich bis 60 kg
type A, measuring range up to 60 kg



Typ B, Wägebereich von 300 bis 1250 kg
type B, measuring range from 300 to 1250 kg

Type type	Wägebereich measuring range	Dimensionen BxLxH dimensions WxLxH	Auflösung resolution	Fermenter Typ/Grösse fermenter type/size	Art. Nr. Art. no.
A	...60 kg	390 x 530 x 120	0,02kg	KLF	51033
B	...300 kg	610 x 610 x161	0,1kg	L1523, NLF	51034
B	...500 kg	762 x 762 x 161	0,2kg	LP 42...75 l	51035
B	...1250 kg	1016 x 1016 x 171	0,5kg	P 100...300 l	51036

Technische Daten	Technical data			
Gewichtsmesszelle:	load cell:		type A	type B
Widerstand	resistance		350Ω	350Ω
Verstärkungsverhältnis	amplification		1 mV/V	2 mV/V
Exc.	exc.		10V DC	10V DC
Nichtlinearität	non linearity		0,015%	0,03%
Temperatureffekt	temp. effect	zero	0,004%/°C	±0,15%
		span	0,0014%/°C	±0,08%



		A	B	plug pin
Exc.	+	red	white	3/5
Exc.	-	white	green	4/6
signal	+	green	red	1
signal	-	blue	black	2
shield		yellow	orange	7

Steckerbelegung / pin arrangement